

# Arm® A64 Instruction Set Architecture

## Armv8, for Armv8-A architecture profile

**arm**

# Arm A64 Instruction Set Architecture

## Armv8, for Armv8-A architecture profile

Copyright © 2010-2021 Arm Limited (or its affiliates). All rights reserved.

### Release Information

For information on the change history and known issues for this release, see the **Release Notes** in the **A64 ISA XML for Armv8.7 (2021-03)**.

### Proprietary Notice

This document is protected by copyright and other related rights and the practice or implementation of the information contained in this document may be protected by one or more patents or pending patent applications. No part of this document may be reproduced in any form by any means without the express prior written permission of Arm. **No license, express or implied, by estoppel or otherwise to any intellectual property rights is granted by this document unless specifically stated.**

Your access to the information in this document is conditional upon your acceptance that you will not use or permit others to use the information for the purposes of determining whether implementations infringe any third party patents.

THIS DOCUMENT IS PROVIDED “AS IS”. ARM PROVIDES NO REPRESENTATIONS AND NO WARRANTIES, EXPRESS, IMPLIED OR STATUTORY, INCLUDING, WITHOUT LIMITATION, THE IMPLIED WARRANTIES OF MERCHANTABILITY, SATISFACTORY QUALITY, NON-INFRINGEMENT OR FITNESS FOR A PARTICULAR PURPOSE WITH RESPECT TO THE DOCUMENT. For the avoidance of doubt, Arm makes no representation with respect to, and has undertaken no analysis to identify or understand the scope and content of, patents, copyrights, trade secrets, or other rights.

This document may include technical inaccuracies or typographical errors.

TO THE EXTENT NOT PROHIBITED BY LAW, IN NO EVENT WILL ARM BE LIABLE FOR ANY DAMAGES, INCLUDING WITHOUT LIMITATION ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, PUNITIVE, OR CONSEQUENTIAL DAMAGES, HOWEVER CAUSED AND REGARDLESS OF THE THEORY OF LIABILITY, ARISING OUT OF ANY USE OF THIS DOCUMENT, EVEN IF ARM HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

This document consists solely of commercial items. You shall be responsible for ensuring that any use, duplication or disclosure of this document complies fully with any relevant export laws and regulations to assure that this document or any portion thereof is not exported, directly or indirectly, in violation of such export laws. Use of the word “partner” in reference to Arm’s customers is not intended to create or refer to any partnership relationship with any other company. Arm may make changes to this document at any time and without notice.

This document may be translated into other languages for convenience, and you agree that if there is any conflict between the English version of this document and any translation, the terms of the English version of the Agreement shall prevail.

The Arm corporate logo and words marked with ™ or ® are registered trademarks or trademarks of Arm Limited (or its affiliates) in the US and/or elsewhere. All rights reserved. Other brands and names mentioned in this document may be the trademarks of their respective owners. You must follow the Arm’s trademark usage guidelines <http://www.arm.com/company/policies/trademarks>.

Copyright © 2010-2021 Arm Limited (or its affiliates). All rights reserved.

Arm Limited. Company 02557590 registered in England.  
110 Fulbourn Road, Cambridge, England CB1 9NJ.

(LES-PRE-20349 version 21.0)

### Confidentiality Status

This document is Non-Confidential. The right to use, copy and disclose this document may be subject to license restrictions in accordance with the terms of the agreement entered into by Arm and the party that Arm delivered this document to.

### Product Status

The information in this document is at Beta quality. Beta quality means that all major features of the specification are included, some details might be missing.

### Web Address

<http://www.arm.com>

### Progressive Terminology Commitment

Arm values inclusive communities. Arm recognizes that we and our industry have used terms that can be offensive. Arm strives to lead the industry and create change.

Previous issues of this document included terms that can be offensive. We have replaced these terms. If you find offensive terms in this document, please contact [terms@arm.com](mailto:terms@arm.com).



## A64 -- Base Instructions (alphabetic order)

[ADC](#): Add with Carry.

[ADCS](#): Add with Carry, setting flags.

[ADD \(extended register\)](#): Add (extended register).

[ADD \(immediate\)](#): Add (immediate).

[ADD \(shifted register\)](#): Add (shifted register).

[ADDG](#): Add with Tag.

[ADDS \(extended register\)](#): Add (extended register), setting flags.

[ADDS \(immediate\)](#): Add (immediate), setting flags.

[ADDS \(shifted register\)](#): Add (shifted register), setting flags.

[ADR](#): Form PC-relative address.

[ADRP](#): Form PC-relative address to 4KB page.

[AND \(immediate\)](#): Bitwise AND (immediate).

[AND \(shifted register\)](#): Bitwise AND (shifted register).

[ANDS \(immediate\)](#): Bitwise AND (immediate), setting flags.

[ANDS \(shifted register\)](#): Bitwise AND (shifted register), setting flags.

[ASR \(immediate\)](#): Arithmetic Shift Right (immediate): an alias of SBFM.

[ASR \(register\)](#): Arithmetic Shift Right (register): an alias of ASRV.

[ASRV](#): Arithmetic Shift Right Variable.

[AT](#): Address Translate: an alias of SYS.

[AUTDA, AUTDZA](#): Authenticate Data address, using key A.

[AUTDB, AUTDZB](#): Authenticate Data address, using key B.

[AUTIA, AUTIA1716, AUTIASP, AUTIAZ, AUTIZA](#): Authenticate Instruction address, using key A.

[AUTIB, AUTIB1716, AUTIBSP, AUTIBZ, AUTIZB](#): Authenticate Instruction address, using key B.

[AXFLAG](#): Convert floating-point condition flags from Arm to external format.

[B](#): Branch.

[B.cond](#): Branch conditionally.

[BFC](#): Bitfield Clear: an alias of BFM.

[BFI](#): Bitfield Insert: an alias of BFM.

[BFM](#): Bitfield Move.

[BFXIL](#): Bitfield extract and insert at low end: an alias of BFM.

[BIC \(shifted register\)](#): Bitwise Bit Clear (shifted register).

[BICS \(shifted register\)](#): Bitwise Bit Clear (shifted register), setting flags.

[BL](#): Branch with Link.

[BLR](#): Branch with Link to Register.

[BLRAA](#), [BLRAAZ](#), [BLRAB](#), [BLRABZ](#): Branch with Link to Register, with pointer authentication.

[BR](#): Branch to Register.

[BRAA](#), [BRAAZ](#), [BRAB](#), [BRABZ](#): Branch to Register, with pointer authentication.

[BRK](#): Breakpoint instruction.

[BTI](#): Branch Target Identification.

[CAS](#), [CASA](#), [CASAL](#), [CASL](#): Compare and Swap word or doubleword in memory.

[CASB](#), [CASAB](#), [CASALB](#), [CASLB](#): Compare and Swap byte in memory.

[CASH](#), [CASAHL](#), [CASALH](#), [CASLH](#): Compare and Swap halfword in memory.

[CASP](#), [CASPA](#), [CASPAL](#), [CASPL](#): Compare and Swap Pair of words or doublewords in memory.

[CBNZ](#): Compare and Branch on Nonzero.

[CBZ](#): Compare and Branch on Zero.

[CCMN \(immediate\)](#): Conditional Compare Negative (immediate).

[CCMN \(register\)](#): Conditional Compare Negative (register).

[CCMP \(immediate\)](#): Conditional Compare (immediate).

[CCMP \(register\)](#): Conditional Compare (register).

[CFINV](#): Invert Carry Flag.

[CFP](#): Control Flow Prediction Restriction by Context: an alias of SYS.

[CINC](#): Conditional Increment: an alias of CSINC.

[CINV](#): Conditional Invert: an alias of CSINV.

[CLREX](#): Clear Exclusive.

[CLS](#): Count Leading Sign bits.

[CLZ](#): Count Leading Zeros.

[CMN \(extended register\)](#): Compare Negative (extended register): an alias of ADDS (extended register).

[CMN \(immediate\)](#): Compare Negative (immediate): an alias of ADDS (immediate).

[CMN \(shifted register\)](#): Compare Negative (shifted register): an alias of ADDS (shifted register).

[CMP \(extended register\)](#): Compare (extended register): an alias of SUBS (extended register).

[CMP \(immediate\)](#): Compare (immediate): an alias of SUBS (immediate).

[CMP \(shifted register\)](#): Compare (shifted register): an alias of SUBS (shifted register).

[CMPP](#): Compare with Tag: an alias of SUBPS.

[CNEG](#): Conditional Negate: an alias of CSNEG.

[CPP](#): Cache Prefetch Prediction Restriction by Context: an alias of SYS.

[CRC32B](#), [CRC32H](#), [CRC32W](#), [CRC32X](#): CRC32 checksum.

[CRC32CB](#), [CRC32CH](#), [CRC32CW](#), [CRC32CX](#): CRC32C checksum.

[CSDB](#): Consumption of Speculative Data Barrier.

[CSEL](#): Conditional Select.

[CSET](#): Conditional Set: an alias of CSINC.

[CSETM](#): Conditional Set Mask: an alias of CSINV.

[CSINC](#): Conditional Select Increment.

[CSINV](#): Conditional Select Invert.

[CSNEG](#): Conditional Select Negation.

[DC](#): Data Cache operation: an alias of SYS.

[DCPS1](#): Debug Change PE State to EL1..

[DCPS2](#): Debug Change PE State to EL2..

[DCPS3](#): Debug Change PE State to EL3.

[DGH](#): Data Gathering Hint.

[DMB](#): Data Memory Barrier.

[DRPS](#): Debug restore process state.

[DSB](#): Data Synchronization Barrier.

[DVP](#): Data Value Prediction Restriction by Context: an alias of SYS.

[EON \(shifted register\)](#): Bitwise Exclusive OR NOT (shifted register).

[EOR \(immediate\)](#): Bitwise Exclusive OR (immediate).

[EOR \(shifted register\)](#): Bitwise Exclusive OR (shifted register).

[ERET](#): Exception Return.

[ERETAA](#), [ERETAB](#): Exception Return, with pointer authentication.

[ESB](#): Error Synchronization Barrier.

[EXTR](#): Extract register.

[GMI](#): Tag Mask Insert.

[HINT](#): Hint instruction.

[HLT](#): Halt instruction.

[HVC](#): Hypervisor Call.

[IC](#): Instruction Cache operation: an alias of SYS.

[IRG](#): Insert Random Tag.

[ISB](#): Instruction Synchronization Barrier.

[LD64B](#): Single-copy Atomic 64-byte Load.

[LDADD](#), [LDADDA](#), [LDADDAL](#), [LDADDL](#): Atomic add on word or doubleword in memory.

[LDADDB](#), [LDADDAB](#), [LDADDALB](#), [LDADDLB](#): Atomic add on byte in memory.

[LDADDH](#), [LDADDAH](#), [LDADDALH](#), [LDADDLH](#): Atomic add on halfword in memory.

[LDAPR](#): Load-Acquire RCpc Register.

[LDAPRB](#): Load-Acquire RCpc Register Byte.

[LDAPRH](#): Load-Acquire RCpc Register Halfword.

[LDAPUR](#): Load-Acquire RCpc Register (unscaled).

[LDAPURB](#): Load-Acquire RCpc Register Byte (unscaled).

[LDAPURH](#): Load-Acquire RCpc Register Halfword (unscaled).

[LDAPURSB](#): Load-Acquire RCpc Register Signed Byte (unscaled).

[LDAPURSH](#): Load-Acquire RCpc Register Signed Halfword (unscaled).

[LDAPURSW](#): Load-Acquire RCpc Register Signed Word (unscaled).

[LDAR](#): Load-Acquire Register.

[LDARB](#): Load-Acquire Register Byte.

[LDARH](#): Load-Acquire Register Halfword.

[LDAXP](#): Load-Acquire Exclusive Pair of Registers.

[LDAXR](#): Load-Acquire Exclusive Register.

[LDAXRB](#): Load-Acquire Exclusive Register Byte.

[LDAXRH](#): Load-Acquire Exclusive Register Halfword.

[LDCLR](#), [LDCLRA](#), [LDCLRAL](#), [LDCLRL](#): Atomic bit clear on word or doubleword in memory.

[LDCLRB](#), [LDCLRAB](#), [LDCLRALB](#), [LDCLRLB](#): Atomic bit clear on byte in memory.

[LDCLRH](#), [LDCLRAH](#), [LDCLRALH](#), [LDCLRLH](#): Atomic bit clear on halfword in memory.

[LDEOR](#), [LDEORA](#), [LDEORAL](#), [LDEORL](#): Atomic exclusive OR on word or doubleword in memory.

[LDEORB](#), [LDEORAB](#), [LDEORALB](#), [LDEORLB](#): Atomic exclusive OR on byte in memory.

[LDEORH](#), [LDEORAH](#), [LDEORALH](#), [LDEORLH](#): Atomic exclusive OR on halfword in memory.

[LDG](#): Load Allocation Tag.

[LDGM](#): Load Tag Multiple.

[LDLAR](#): Load LOAcquire Register.

[LDLARB](#): Load LOAcquire Register Byte.

[LDLARH](#): Load LOAcquire Register Halfword.

[LDNP](#): Load Pair of Registers, with non-temporal hint.

[LDP](#): Load Pair of Registers.

[LDPSW](#): Load Pair of Registers Signed Word.

[LDR \(immediate\)](#): Load Register (immediate).

[LDR \(literal\)](#): Load Register (literal).

[LDR \(register\)](#): Load Register (register).

[LDRAA](#), [LDRAB](#): Load Register, with pointer authentication.

[LDRB \(immediate\)](#): Load Register Byte (immediate).

[LDRB \(register\)](#): Load Register Byte (register).

[LDRH \(immediate\)](#): Load Register Halfword (immediate).

[LDRH \(register\)](#): Load Register Halfword (register).

[LDRSB \(immediate\)](#): Load Register Signed Byte (immediate).

[LDRSB \(register\)](#): Load Register Signed Byte (register).

[LDRSH \(immediate\)](#): Load Register Signed Halfword (immediate).



[LDRSH \(register\)](#): Load Register Signed Halfword (register).

[LDRSW \(immediate\)](#): Load Register Signed Word (immediate).

[LDRSW \(literal\)](#): Load Register Signed Word (literal).

[LDRSW \(register\)](#): Load Register Signed Word (register).

[LDSET](#), [LDSETA](#), [LDSETAL](#), [LDSETL](#): Atomic bit set on word or doubleword in memory.

[LDSETB](#), [LDSETAB](#), [LDSETALB](#), [LDSETLB](#): Atomic bit set on byte in memory.

[LDSETH](#), [LDSETAH](#), [LDSETALH](#), [LDSETLH](#): Atomic bit set on halfword in memory.

[LDSMAX](#), [LDSMAXA](#), [LDSMAXAL](#), [LDSMAXL](#): Atomic signed maximum on word or doubleword in memory.

[LDSMAXB](#), [LDSMAXAB](#), [LDSMAXALB](#), [LDSMAXLB](#): Atomic signed maximum on byte in memory.

[LDSMAXH](#), [LDSMAXAH](#), [LDSMAXALH](#), [LDSMAXLH](#): Atomic signed maximum on halfword in memory.

[LDSMIN](#), [LDSMINA](#), [LDSMINAL](#), [LDSMINL](#): Atomic signed minimum on word or doubleword in memory.

[LDSMINB](#), [LDSMINAB](#), [LDSMINALB](#), [LDSMINLB](#): Atomic signed minimum on byte in memory.

[LDSMINH](#), [LDSMINAH](#), [LDSMINALH](#), [LDSMINLH](#): Atomic signed minimum on halfword in memory.

[LDTR](#): Load Register (unprivileged).

[LDTRB](#): Load Register Byte (unprivileged).

[LDTRH](#): Load Register Halfword (unprivileged).

[LDTRSB](#): Load Register Signed Byte (unprivileged).

[LDTRSH](#): Load Register Signed Halfword (unprivileged).

[LDTRSW](#): Load Register Signed Word (unprivileged).

[LDUMAX](#), [LDUMAXA](#), [LDUMAXAL](#), [LDUMAXL](#): Atomic unsigned maximum on word or doubleword in memory.

[LDUMAXB](#), [LDUMAXAB](#), [LDUMAXALB](#), [LDUMAXLB](#): Atomic unsigned maximum on byte in memory.

[LDUMAXH](#), [LDUMAXAH](#), [LDUMAXALH](#), [LDUMAXLH](#): Atomic unsigned maximum on halfword in memory.

[LDUMIN](#), [LDUMINA](#), [LDUMINAL](#), [LDUMINL](#): Atomic unsigned minimum on word or doubleword in memory.

[LDUMINB](#), [LDUMINAB](#), [LDUMINALB](#), [LDUMINLB](#): Atomic unsigned minimum on byte in memory.

[LDUMINH](#), [LDUMINAH](#), [LDUMINALH](#), [LDUMINLH](#): Atomic unsigned minimum on halfword in memory.

[LDUR](#): Load Register (unscaled).

[LDURB](#): Load Register Byte (unscaled).

[LDURH](#): Load Register Halfword (unscaled).

[LDURSB](#): Load Register Signed Byte (unscaled).

[LDURSH](#): Load Register Signed Halfword (unscaled).

[LDURSW](#): Load Register Signed Word (unscaled).

[LDXP](#): Load Exclusive Pair of Registers.

[LDXR](#): Load Exclusive Register.

[LDXRB](#): Load Exclusive Register Byte.

[LDXRH](#): Load Exclusive Register Halfword.

[LSL \(immediate\)](#): Logical Shift Left (immediate): an alias of UBFM.

[LSL \(register\)](#): Logical Shift Left (register): an alias of LSLV.

[LSLV](#): Logical Shift Left Variable.

[LSR \(immediate\)](#): Logical Shift Right (immediate): an alias of UBFM.

[LSR \(register\)](#): Logical Shift Right (register): an alias of LSRV.

[LSRV](#): Logical Shift Right Variable.

[MADD](#): Multiply-Add.

[MNEG](#): Multiply-Negate: an alias of MSUB.

[MOV \(bitmask immediate\)](#): Move (bitmask immediate): an alias of ORR (immediate).

[MOV \(inverted wide immediate\)](#): Move (inverted wide immediate): an alias of MOVN.

[MOV \(register\)](#): Move (register): an alias of ORR (shifted register).

[MOV \(to/from SP\)](#): Move between register and stack pointer: an alias of ADD (immediate).

[MOV \(wide immediate\)](#): Move (wide immediate): an alias of MOVZ.

[MOVK](#): Move wide with keep.

[MOVN](#): Move wide with NOT.

[MOVZ](#): Move wide with zero.

[MRS](#): Move System Register.

[MSR \(immediate\)](#): Move immediate value to Special Register.

[MSR \(register\)](#): Move general-purpose register to System Register.

[MSUB](#): Multiply-Subtract.

[MUL](#): Multiply: an alias of MADD.

[MVN](#): Bitwise NOT: an alias of ORN (shifted register).

[NEG \(shifted register\)](#): Negate (shifted register): an alias of SUB (shifted register).

[NEGS](#): Negate, setting flags: an alias of SUBS (shifted register).

[NGC](#): Negate with Carry: an alias of SBC.

[NGCS](#): Negate with Carry, setting flags: an alias of SBCS.

[NOP](#): No Operation.

[ORN \(shifted register\)](#): Bitwise OR NOT (shifted register).

[ORR \(immediate\)](#): Bitwise OR (immediate).

[ORR \(shifted register\)](#): Bitwise OR (shifted register).

[PACDA, PACDZA](#): Pointer Authentication Code for Data address, using key A.

[PACDB, PACDZB](#): Pointer Authentication Code for Data address, using key B.

[PACGA](#): Pointer Authentication Code, using Generic key.

[PACIA, PACIA1716, PACIASP, PACIAZ, PACIZA](#): Pointer Authentication Code for Instruction address, using key A.

[PACIB, PACIB1716, PACIBSP, PACIBZ, PACIZB](#): Pointer Authentication Code for Instruction address, using key B.

[PRFM \(immediate\)](#): Prefetch Memory (immediate).

[PRFM \(literal\)](#): Prefetch Memory (literal).

[PRFM \(register\)](#): Prefetch Memory (register).

[PRFUM](#): Prefetch Memory (unscaled offset).

[PSB CSYNC](#): Profiling Synchronization Barrier.

[PSSBB](#): Physical Speculative Store Bypass Barrier: an alias of DSB.

[RBIT](#): Reverse Bits.

[RET](#): Return from subroutine.

[RETAA, RETAB](#): Return from subroutine, with pointer authentication.

[REV](#): Reverse Bytes.

[REV16](#): Reverse bytes in 16-bit halfwords.

[REV32](#): Reverse bytes in 32-bit words.

[REV64](#): Reverse Bytes: an alias of REV.

[RMIF](#): Rotate, Mask Insert Flags.

[ROR \(immediate\)](#): Rotate right (immediate): an alias of EXTR.

[ROR \(register\)](#): Rotate Right (register): an alias of RORV.

[RORV](#): Rotate Right Variable.

[SB](#): Speculation Barrier.

[SBC](#): Subtract with Carry.

[SBCS](#): Subtract with Carry, setting flags.

[SBFIZ](#): Signed Bitfield Insert in Zero: an alias of SBFM.

[SBFM](#): Signed Bitfield Move.

[SBFX](#): Signed Bitfield Extract: an alias of SBFM.

[SDIV](#): Signed Divide.

[SETF8, SETF16](#): Evaluation of 8 or 16 bit flag values.

[SEV](#): Send Event.

[SEVL](#): Send Event Local.

[SMADDL](#): Signed Multiply-Add Long.

[SMC](#): Secure Monitor Call.

[SMNEGL](#): Signed Multiply-Negate Long: an alias of SMSUBL.

[SMSUBL](#): Signed Multiply-Subtract Long.

[SMULH](#): Signed Multiply High.

[SMULL](#): Signed Multiply Long: an alias of SMADDL.

[SSBB](#): Speculative Store Bypass Barrier: an alias of DSB.

[ST2G](#): Store Allocation Tags.

[ST64B](#): Single-copy Atomic 64-byte Store without Return.

[ST64BV](#): Single-copy Atomic 64-byte Store with Return.

[ST64BV0](#): Single-copy Atomic 64-byte EL0 Store with Return.

[STADD, STADDL](#): Atomic add on word or doubleword in memory, without return: an alias of LDADD, LDADDA, LDADDAL, LDADDL.

[STADDB, STADDLB](#): Atomic add on byte in memory, without return: an alias of LDADDB, LDADDAB, LDADDALB, LDADDLB.

[STADDH, STADDLH](#): Atomic add on halfword in memory, without return: an alias of LDADDH, LDADDAH, LDADDALH, LDADDLH.

[STCLR, STCLRL](#): Atomic bit clear on word or doubleword in memory, without return: an alias of LDCLR, LDCLRA, LDCLRAL, LDCLRL.

[STCLRB, STCLRLB](#): Atomic bit clear on byte in memory, without return: an alias of LDCLRB, LDCLRAB, LDCLRALB, LDCLRLB.

[STCLRH, STCLRLH](#): Atomic bit clear on halfword in memory, without return: an alias of LDCLRH, LDCLRAH, LDCLRALH, LDCLRLH.

[STEOR, STEORL](#): Atomic exclusive OR on word or doubleword in memory, without return: an alias of LDEOR, LDEORA, LDEORAL, LDEORL.

[STEORB, STEORLB](#): Atomic exclusive OR on byte in memory, without return: an alias of LDEORB, LDEORAB, LDEORALB, LDEORLB.

[STEORH, STEORLH](#): Atomic exclusive OR on halfword in memory, without return: an alias of LDEORH, LDEORAH, LDEORALH, LDEORLH.

[STG](#): Store Allocation Tag.

[STGM](#): Store Tag Multiple.

[STGP](#): Store Allocation Tag and Pair of registers.

[STLLR](#): Store LORelease Register.

[STLLRB](#): Store LORelease Register Byte.

[STLLRH](#): Store LORelease Register Halfword.

[STLR](#): Store-Release Register.

[STLRB](#): Store-Release Register Byte.

[STLRH](#): Store-Release Register Halfword.

[STLUR](#): Store-Release Register (unscaled).

[STLURB](#): Store-Release Register Byte (unscaled).

[STLURH](#): Store-Release Register Halfword (unscaled).

[STLXP](#): Store-Release Exclusive Pair of registers.

[STLXR](#): Store-Release Exclusive Register.

[STLXRB](#): Store-Release Exclusive Register Byte.

[STLXRH](#): Store-Release Exclusive Register Halfword.

[STNP](#): Store Pair of Registers, with non-temporal hint.

[STP](#): Store Pair of Registers.

[STR \(immediate\)](#): Store Register (immediate).

[STR \(register\)](#): Store Register (register).

[STRB \(immediate\)](#): Store Register Byte (immediate).

[STRB \(register\)](#): Store Register Byte (register).

[STRH \(immediate\)](#): Store Register Halfword (immediate).

[STRH \(register\)](#): Store Register Halfword (register).

[STSET, STSETL](#): Atomic bit set on word or doubleword in memory, without return: an alias of LDSET, LDSETA, LDSETAL, LDSETL.

[STSETB, STSETLB](#): Atomic bit set on byte in memory, without return: an alias of LDSETB, LDSETAB, LDSETALB, LDSETLB.

[STSETH, STSETLH](#): Atomic bit set on halfword in memory, without return: an alias of LDSETH, LDSETHA, LDSETALH, LDSETLH.

[STSMAX, STSMAXL](#): Atomic signed maximum on word or doubleword in memory, without return: an alias of LDSMAX, LDSMAXA, LDSMAXAL, LDSMAXL.

[STSMAXB, STSMAXLB](#): Atomic signed maximum on byte in memory, without return: an alias of LDSMAXB, LDSMAXAB, LDSMAXALB, LDSMAXLB.

[STSMAXH, STSMAXLH](#): Atomic signed maximum on halfword in memory, without return: an alias of LDSMAXH, LDSMAXAH, LDSMAXALH, LDSMAXLH.

[STSMIN, STSMINL](#): Atomic signed minimum on word or doubleword in memory, without return: an alias of LDSMIN, LDSMINA, LDSMINAL, LDSMINL.

[STSMINB, STSMINLB](#): Atomic signed minimum on byte in memory, without return: an alias of LDSMINB, LDSMINAB, LDSMINALB, LDSMINLB.

[STSMINH, STSMINLH](#): Atomic signed minimum on halfword in memory, without return: an alias of LDSMINH, LDSMINAH, LDSMINALH, LDSMINLH.

[STTR](#): Store Register (unprivileged).

[STTRB](#): Store Register Byte (unprivileged).

[STTRH](#): Store Register Halfword (unprivileged).

[STUMAX, STUMAXL](#): Atomic unsigned maximum on word or doubleword in memory, without return: an alias of LDUMAX, LDUMAXA, LDUMAXAL, LDUMAXL.

[STUMAXB, STUMAXLB](#): Atomic unsigned maximum on byte in memory, without return: an alias of LDUMAXB, LDUMAXAB, LDUMAXALB, LDUMAXLB.

[STUMAXH, STUMAXLH](#): Atomic unsigned maximum on halfword in memory, without return: an alias of LDUMAXH, LDUMAXAH, LDUMAXALH, LDUMAXLH.

[STUMIN, STUMINL](#): Atomic unsigned minimum on word or doubleword in memory, without return: an alias of LDUMIN, LDUMINA, LDUMINAL, LDUMINL.

[STUMINB, STUMINLB](#): Atomic unsigned minimum on byte in memory, without return: an alias of LDUMINB, LDUMINAB, LDUMINALB, LDUMINLB.

[STUMINH, STUMINLH](#): Atomic unsigned minimum on halfword in memory, without return: an alias of LDUMINH, LDUMINAH, LDUMINALH, LDUMINLH.

[STUR](#): Store Register (unscaled).

[STURB](#): Store Register Byte (unscaled).

[STURH](#): Store Register Halfword (unscaled).

[STXP](#): Store Exclusive Pair of registers.

[STXR](#): Store Exclusive Register.

[STXRB](#): Store Exclusive Register Byte.

[STXRH](#): Store Exclusive Register Halfword.

[STZ2G](#): Store Allocation Tags, Zeroing.

[STZG](#): Store Allocation Tag, Zeroing.

[STZGM](#): Store Tag and Zero Multiple.

[SUB \(extended register\)](#): Subtract (extended register).

[SUB \(immediate\)](#): Subtract (immediate).

[SUB \(shifted register\)](#): Subtract (shifted register).

[SUBG](#): Subtract with Tag.

[SUBP](#): Subtract Pointer.

[SUBPS](#): Subtract Pointer, setting Flags.

[SUBS \(extended register\)](#): Subtract (extended register), setting flags.

[SUBS \(immediate\)](#): Subtract (immediate), setting flags.

[SUBS \(shifted register\)](#): Subtract (shifted register), setting flags.

[SVC](#): Supervisor Call.

[SWP, SWPA, SWPAL, SWPL](#): Swap word or doubleword in memory.

[SWPB, SWPAB, SWPALB, SWPLB](#): Swap byte in memory.

[SWPH, SWPAH, SWPALH, SWPLH](#): Swap halfword in memory.

[SXTB](#): Signed Extend Byte: an alias of SBFM.

[SXTH](#): Sign Extend Halfword: an alias of SBFM.

[SXTW](#): Sign Extend Word: an alias of SBFM.

[SYS](#): System instruction.

[SYSL](#): System instruction with result.

[TBNZ](#): Test bit and Branch if Nonzero.

[TBZ](#): Test bit and Branch if Zero.

[TLBI](#): TLB Invalidate operation: an alias of SYS.

[TSB CSYNC](#): Trace Synchronization Barrier.

[TST \(immediate\)](#): Test bits (immediate): an alias of ANDS (immediate).

[TST \(shifted register\)](#): Test (shifted register): an alias of ANDS (shifted register).

[UBFIZ](#): Unsigned Bitfield Insert in Zero: an alias of UBFM.

[UBFM](#): Unsigned Bitfield Move.

[UBFX](#): Unsigned Bitfield Extract: an alias of UBFM.

[UDF](#): Permanently Undefined.

[UDIV](#): Unsigned Divide.

[UMADDL](#): Unsigned Multiply-Add Long.

[UMNEGL](#): Unsigned Multiply-Negate Long: an alias of UMSUBL.

[UMSUBL](#): Unsigned Multiply-Subtract Long.

[UMULH](#): Unsigned Multiply High.

[UMULL](#): Unsigned Multiply Long: an alias of UMADDL.

[UXTB](#): Unsigned Extend Byte: an alias of UBFM.

[UXTH](#): Unsigned Extend Halfword: an alias of UBFM.

[WFE](#): Wait For Event.

[WFET](#): Wait For Event with Timeout.

[WFI](#): Wait For Interrupt.

[WFIT](#): Wait For Interrupt with Timeout.

[XAFLAG](#): Convert floating-point condition flags from external format to Arm format.

[XPACD](#), [XPACL](#), [XPACLRI](#): Strip Pointer Authentication Code.

[YIELD](#): YIELD.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## ADC

Add with Carry adds two register values and the Carry flag value, and writes the result to the destination register.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	0	1	1	0	1	0	0	0	0	Rm					0	0	0	0	0	0	Rn					Rd				
op S																															

### 32-bit (sf == 0)

ADC <Wd>, <Wn>, <Wm>

### 64-bit (sf == 1)

ADC <Xd>, <Xn>, <Xm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
```

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Wm>	Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = X[m];

(result, -) = AddWithCarry(operand1, operand2, PSTATE.C);

X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



## ADCS

Add with Carry, setting flags, adds two register values and the Carry flag value, and writes the result to the destination register. It updates the condition flags based on the result.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	1	1	1	0	1	0	0	0	0	Rm					0	0	0	0	0	0	Rn					Rd				
op S																															

### 32-bit (sf == 0)

ADCS <Wd>, <Wn>, <Wm>

### 64-bit (sf == 1)

ADCS <Xd>, <Xn>, <Xm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
```

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Wm>	Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = X[m];
bits(4) nzcvc;

(result, nzcvc) = AddWithCarry(operand1, operand2, PSTATE.C);

PSTATE.<N,Z,C,V> = nzcvc;

X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

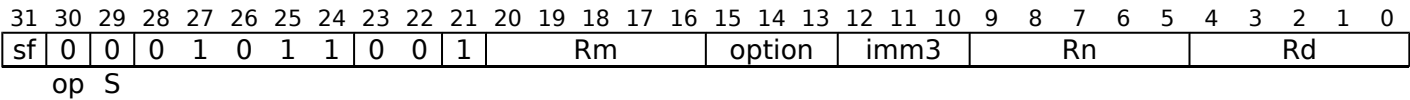
- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# ADD (extended register)

Add (extended register) adds a register value and a sign or zero-extended register value, followed by an optional left shift amount, and writes the result to the destination register. The argument that is extended from the <Rm> register can be a byte, halfword, word, or doubleword.



## 32-bit (sf == 0)

ADD <Wd|WSP>, <Wn|WSP>, <Wm>{, <extend> {#<amount>}}

## 64-bit (sf == 1)

ADD <Xd|SP>, <Xn|SP>, <R><m>{, <extend> {#<amount>}}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
ExtendType extend_type = DecodeRegExtend(option);
integer shift = UInt(imm3);
if shift > 4 then UNDEFINED;
```

## Assembler Symbols

- <Wd|WSP> Is the 32-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Wn|WSP> Is the 32-bit name of the first source general-purpose register or stack pointer, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd|SP> Is the 64-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Xn|SP> Is the 64-bit name of the first source general-purpose register or stack pointer, encoded in the "Rn" field.
- <R> Is a width specifier, encoded in "option":

option	<R>
00x	W
010	W
x11	X
10x	W
110	W
- <m> Is the number [0-30] of the second general-purpose source register or the name ZR (31), encoded in the "Rm" field.
- <extend> For the 32-bit variant: is the extension to be applied to the second source operand, encoded in "option":

option	<extend>
000	UXTB
001	UXTH
010	LSL UXTW
011	UXTX
100	SXTB
101	SXTH
110	SXTW
111	SXTX

If "Rd" or "Rn" is '11111' (WSP) and "option" is '010' then LSL is preferred, but may be omitted when "imm3" is '000'. In all other cases <extend> is required and must be UXTW when "option" is '010'.

For the 64-bit variant: is the extension to be applied to the second source operand, encoded in "option":

option	<extend>
000	UXTB
001	UXTH
010	UXTW
011	LSL UXTX
100	SXTB
101	SXTH
110	SXTW
111	SXTX

If "Rd" or "Rn" is '11111' (SP) and "option" is '011' then LSL is preferred, but may be omitted when "imm3" is '000'. In all other cases <extend> is required and must be UXTX when "option" is '011'.

<amount> Is the left shift amount to be applied after extension in the range 0 to 4, defaulting to 0, encoded in the "imm3" field. It must be absent when <extend> is absent, is required when <extend> is LSL, and is optional when <extend> is present but not LSL.

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = if n == 31 then SP[] else X[n];
bits(datasize) operand2 = ExtendReg(m, extend_type, shift);

(result, -) = AddWithCarry(operand1, operand2, '0');

if d == 31 then
    SP[] = result;
else
    X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## ADD (immediate)

Add (immediate) adds a register value and an optionally-shifted immediate value, and writes the result to the destination register.

This instruction is used by the alias [MOV \(to/from SP\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0										
sf		0		0		1		0		0		0		1		0		sh		imm12												Rn					Rd				
op S																																									

### 32-bit (sf == 0)

ADD <Wd|WSP>, <Wn|WSP>, #<imm>{, <shift>}

### 64-bit (sf == 1)

ADD <Xd|SP>, <Xn|SP>, #<imm>{, <shift>}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer datasize = if sf == '1' then 64 else 32;
bits(datasize) imm;

case sh of
  when '0' imm = ZeroExtend(imm12, datasize);
  when '1' imm = ZeroExtend(imm12:Zeros(12), datasize);
```

## Assembler Symbols

- |          |   |
|----------|---|
| <Wd WSP> | Is the 32-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field. |
| <Wn WSP> | Is the 32-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.      |
| <Xd SP>  | Is the 64-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field. |
| <Xn SP>  | Is the 64-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.      |
| <imm>    | Is an unsigned immediate, in the range 0 to 4095, encoded in the "imm12" field.                             |
| <shift>  | Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":             |

sh	<shift>
0	LSL #0
1	LSL #12

## Alias Conditions

Alias	Is preferred when
<a href="#">MOV (to/from SP)</a>	sh == '0' && imm12 == '000000000000' && (Rd == '11111'    Rn == '11111')

## Operation

```
bits(datasize) result;  
bits(datasize) operand1 = if n == 31 then SP[] else X[n];  
  
(result, -) = AddWithCarry(operand1, imm, '0');  
  
if d == 31 then  
    SP[] = result;  
else  
    X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## ADD (shifted register)

Add (shifted register) adds a register value and an optionally-shifted register value, and writes the result to the destination register.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	0	0	1	0	1	1	shift	0	Rm						imm6						Rn						Rd			
op S																															

### 32-bit (sf == 0)

ADD <Wd>, <Wn>, <Wm>{, <shift> #<amount>}

### 64-bit (sf == 1)

ADD <Xd>, <Xn>, <Xm>{, <shift> #<amount>}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;

if shift == '11' then UNDEFINED;
if sf == '0' && imm6<5> == '1' then UNDEFINED;

ShiftType shift_type = DecodeShift(shift);
integer shift_amount = UInt(imm6);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <shift> Is the optional shift type to be applied to the second source operand, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	RESERVED

- <amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.  
For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field.

## Operation

```
bits(datasize) result;  
bits(datasize) operand1 = X[n];  
bits(datasize) operand2 = ShiftReg(m, shift_type, shift_amount);  
  
(result, -) = AddWithCarry(operand1, operand2, '0');  
  
X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

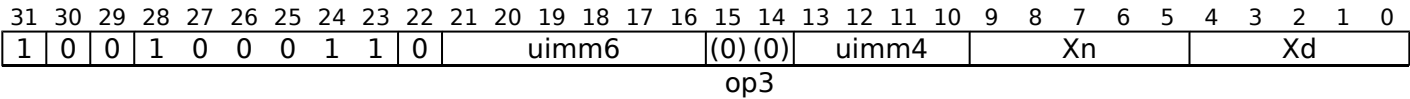
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

ADDG

Add with Tag adds an immediate value scaled by the Tag granule to the address in the source register, modifies the Logical Address Tag of the address using an immediate value, and writes the result to the destination register. Tags specified in GCR\_EL1.Exclude are excluded from the possible outputs when modifying the Logical Address Tag.

Integer  
(FEAT\_MTE)



ADDG <Xd|SP>, <Xn|SP>, #<uimm6>, #<uimm4>

```
if !HaveMTEExt() then UNDEFINED;
integer d = UInt(Xd);
integer n = UInt(Xn);
bits(64) offset = LSL(ZeroExtend(uimm6, 64), LOG2_TAG_GRANULE);
```

Assembler Symbols

- <Xd|SP> Is the 64-bit name of the destination general-purpose register or stack pointer, encoded in the "Xd" field.
- <Xn|SP> Is the 64-bit name of the source general-purpose register or stack pointer, encoded in the "Xn" field.
- <uimm6> Is an unsigned immediate, a multiple of 16 in the range 0 to 1008, encoded in the "uimm6" field.
- <uimm4> Is an unsigned immediate, in the range 0 to 15, encoded in the "uimm4" field.

Operation

```
bits(64) operand1 = if n == 31 then SP[] else X[n];
bits(4) start_tag = AArch64.AllocationTagFromAddress(operand1);
bits(16) exclude = GCR_EL1.Exclude;
bits(64) result;
bits(4) rtag;

if AArch64.AllocationTagAccessIsEnabled(AccType_NORMAL) then
    rtag = AArch64.ChooseNonExcludedTag(start_tag, uimm4, exclude);
else
    rtag = '0000';

(result, -) = AddWithCarry(operand1, offset, '0');
result = AArch64.AddressWithAllocationTag(result, AccType_NORMAL, rtag);

if d == 31 then
    SP[] = result;
else
    X[d] = result;
```



## ADDS (extended register)

Add (extended register), setting flags, adds a register value and a sign or zero-extended register value, followed by an optional left shift amount, and writes the result to the destination register. The argument that is extended from the <Rm> register can be a byte, halfword, word, or doubleword. It updates the condition flags based on the result.

This instruction is used by the alias [CMN \(extended register\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	1	0	1	0	1	1	0	0	1	Rm				option			imm3			Rn				Rd						
op S																															

### 32-bit (sf == 0)

ADDS <Wd>, <Wn|WSP>, <Wm>{, <extend> {#<amount>}}

### 64-bit (sf == 1)

ADDS <Xd>, <Xn|SP>, <R><m>{, <extend> {#<amount>}}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
ExtendType extend_type = DecodeRegExtend(option);
integer shift = UInt(imm3);
if shift > 4 then UNDEFINED;
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn|WSP> Is the 32-bit name of the first source general-purpose register or stack pointer, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn|SP> Is the 64-bit name of the first source general-purpose register or stack pointer, encoded in the "Rn" field.

- <R> Is a width specifier, encoded in "option":

option	<R>
00x	W
010	W
x11	X
10x	W
110	W

- <m> Is the number [0-30] of the second general-purpose source register or the name ZR (31), encoded in the "Rm" field.

- <extend> For the 32-bit variant: is the extension to be applied to the second source operand, encoded in "option":

option	<extend>
000	UXTB
001	UXTH
010	LSL UXTW
011	UXTX
100	SXTB
101	SXTH
110	SXTW
111	SXTX

If "Rn" is '11111' (WSP) and "option" is '010' then LSL is preferred, but may be omitted when "imm3" is '000'. In all other cases <extend> is required and must be UXTW when "option" is '010'.

For the 64-bit variant: is the extension to be applied to the second source operand, encoded in "option":

option	<extend>
000	UXTB
001	UXTH
010	UXTW
011	LSL UXTX
100	SXTB
101	SXTH
110	SXTW
111	SXTX

If "Rn" is '11111' (SP) and "option" is '011' then LSL is preferred, but may be omitted when "imm3" is '000'. In all other cases <extend> is required and must be UXTX when "option" is '011'.

<amount> Is the left shift amount to be applied after extension in the range 0 to 4, defaulting to 0, encoded in the "imm3" field. It must be absent when <extend> is absent, is required when <extend> is LSL, and is optional when <extend> is present but not LSL.

## Alias Conditions

Alias	Is preferred when
<a href="#">CMN (extended register)</a>	Rd == '11111'

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = if n == 31 then SP[] else X[n];
bits(datasize) operand2 = ExtendReg(m, extend_type, shift);
bits(4) nzcvc;

(result, nzcvc) = AddWithCarry(operand1, operand2, '0');

PSTATE.<N,Z,C,V> = nzcvc;

X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

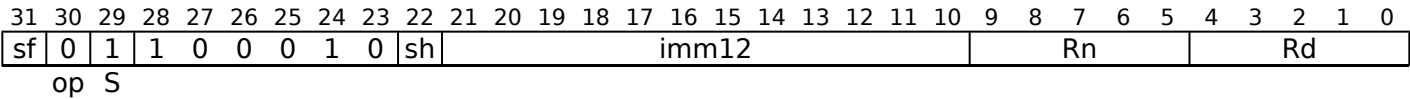
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# ADDS (immediate)

Add (immediate), setting flags, adds a register value and an optionally-shifted immediate value, and writes the result to the destination register. It updates the condition flags based on the result.

This instruction is used by the alias [CMN \(immediate\)](#).



## 32-bit (sf == 0)

ADDS <Wd>, <Wn|WSP>, #<imm>{, <shift>}

## 64-bit (sf == 1)

ADDS <Xd>, <Xn|SP>, #<imm>{, <shift>}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer datasize = if sf == '1' then 64 else 32;
bits(datasize) imm;

case sh of
  when '0' imm = ZeroExtend(imm12, datasize);
  when '1' imm = ZeroExtend(imm12:Zeros(12), datasize);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn|WSP> Is the 32-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn|SP> Is the 64-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.
- <imm> Is an unsigned immediate, in the range 0 to 4095, encoded in the "imm12" field.
- <shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #12

## Alias Conditions

Alias	Is preferred when
<a href="#">CMN (immediate)</a>	Rd == '11111'

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = if n == 31 then SP[] else X[n];
bits(4) nzcvc;

(result, nzcvc) = AddWithCarry(operand1, imm, '0');

PSTATE.<N,Z,C,V> = nzcvc;

X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

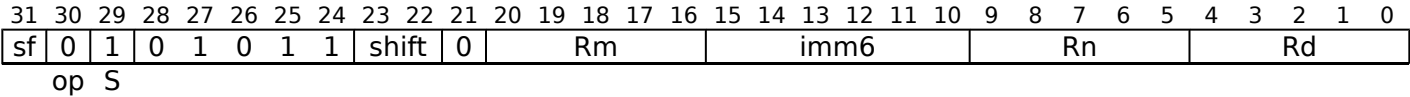
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## ADDS (shifted register)

Add (shifted register), setting flags, adds a register value and an optionally-shifted register value, and writes the result to the destination register. It updates the condition flags based on the result.

This instruction is used by the alias [CMN \(shifted register\)](#).



### 32-bit (sf == 0)

ADDS <Wd>, <Wn>, <Wm>{, <shift> #<amount>}

### 64-bit (sf == 1)

ADDS <Xd>, <Xn>, <Xm>{, <shift> #<amount>}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;

if shift == '11' then UNDEFINED;
if sf == '0' && imm6<5> == '1' then UNDEFINED;

ShiftType shift_type = DecodeShift(shift);
integer shift_amount = UInt(imm6);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <shift> Is the optional shift type to be applied to the second source operand, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	RESERVED

- <amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.  
For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">CMN (shifted register)</a>	Rd == '11111'

## Operation

```
bits(datasize) result;  
bits(datasize) operand1 = X[n];  
bits(datasize) operand2 = ShiftReg(m, shift_type, shift_amount);  
bits(4) nzcvc;  
  
(result, nzcvc) = AddWithCarry(operand1, operand2, '0');  
  
PSTATE.<N,Z,C,V> = nzcvc;  
  
X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

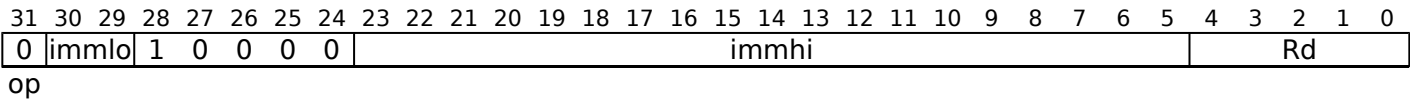
- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

ADR

Form PC-relative address adds an immediate value to the PC value to form a PC-relative address, and writes the result to the destination register.



ADR <Xd>, <label>

```
integer d = UInt(Rd);
bits(64) imm;

imm = SignExtend(immhi:immlo, 64);
```

Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <label> Is the program label whose address is to be calculated. Its offset from the address of this instruction, in the range +/-1MB, is encoded in "immhi:immlo".

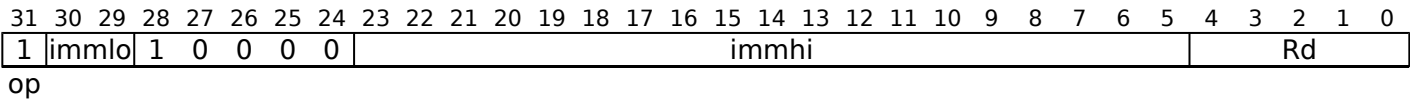
Operation

```
bits(64) base = PC[];

X[d] = base + imm;
```

ADRP

Form PC-relative address to 4KB page adds an immediate value that is shifted left by 12 bits, to the PC value to form a PC-relative address, with the bottom 12 bits masked out, and writes the result to the destination register.



ADRP <Xd>, <label>

```
integer d = UInt(Rd);
bits(64) imm;

imm = SignExtend(immhi:immlo:Zeros(12), 64);
```

Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <label> Is the program label whose 4KB page address is to be calculated. Its offset from the page address of this instruction, in the range +/-4GB, is encoded as "immhi:immlo" times 4096.

Operation

```
bits(64) base = PC[];

base<11:0> = Zeros(12);

X[d] = base + imm;
```



## AND (immediate)

Bitwise AND (immediate) performs a bitwise AND of a register value and an immediate value, and writes the result to the destination register.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	0	1	0	0	1	0	0	N	immr						imms						Rn						Rd			
opc																															

### 32-bit (sf == 0 && N == 0)

AND <Wd|WSP>, <Wn>, #<imm>

### 64-bit (sf == 1)

AND <Xd|SP>, <Xn>, #<imm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer datasize = if sf == '1' then 64 else 32;
bits(datasize) imm;
if sf == '0' && N != '0' then UNDEFINED;
(imm, -) = DecodeBitMasks(N, imms, immr, TRUE);
```

## Assembler Symbols

- <Wd|WSP> Is the 32-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
- <Xd|SP> Is the 64-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
- <imm> For the 32-bit variant: is the bitmask immediate, encoded in "imms:immr".  
For the 64-bit variant: is the bitmask immediate, encoded in "N:imms:immr".

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = X[n];

result = operand1 AND imm;
if d == 31 then
    SP[] = result;
else
    X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## AND (shifted register)

Bitwise AND (shifted register) performs a bitwise AND of a register value and an optionally-shifted register value, and writes the result to the destination register.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	0	0	1	0	1	0	shift	0	Rm						imm6						Rn						Rd			
opc								N																							

### 32-bit (sf == 0)

AND <Wd>, <Wn>, <Wm>{, <shift> #<amount>}

### 64-bit (sf == 1)

AND <Xd>, <Xn>, <Xm>{, <shift> #<amount>}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
if sf == '0' && imm6<5> == '1' then UNDEFINED;

ShiftType shift_type = DecodeShift(shift);
integer shift_amount = UInt(imm6);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <shift> Is the optional shift to be applied to the final source, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	ROR

- <amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.  
For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field,

## Operation

```
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = ShiftReg(m, shift_type, shift_amount);

result = operand1 AND operand2;
X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

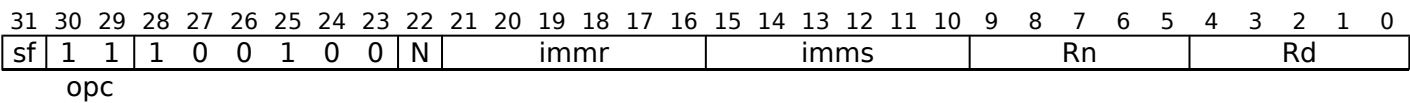
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# ANDS (immediate)

Bitwise AND (immediate), setting flags, performs a bitwise AND of a register value and an immediate value, and writes the result to the destination register. It updates the condition flags based on the result.

This instruction is used by the alias [TST \(immediate\)](#).



## 32-bit (sf == 0 && N == 0)

ANDS <Wd>, <Wn>, #<imm>

## 64-bit (sf == 1)

ANDS <Xd>, <Xn>, #<imm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer datasize = if sf == '1' then 64 else 32;

bits(datasize) imm;
if sf == '0' && N != '0' then UNDEFINED;
(imm, -) = DecodeBitMasks(N, imms, immr, TRUE);
```

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
<imm>	For the 32-bit variant: is the bitmask immediate, encoded in "imms:immr". For the 64-bit variant: is the bitmask immediate, encoded in "N:imms:immr".

## Alias Conditions

Alias	Is preferred when
<a href="#">TST (immediate)</a>	Rd == '11111'

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = X[n];

result = operand1 AND imm;
PSTATE.<N,Z,C,V> = result<datasize-1>:IsZeroBit(result):'00';

X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:

- The values of the data supplied in any of its registers.
- The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## ANDS (shifted register)

Bitwise AND (shifted register), setting flags, performs a bitwise AND of a register value and an optionally-shifted register value, and writes the result to the destination register. It updates the condition flags based on the result.

This instruction is used by the alias [TST \(shifted register\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	1	1	0	1	0	1	0	shift	0	Rm						imm6						Rn						Rd			
opc								N																							

### 32-bit (sf == 0)

ANDS <Wd>, <Wn>, <Wm>{, <shift> #<amount>}

### 64-bit (sf == 1)

ANDS <Xd>, <Xn>, <Xm>{, <shift> #<amount>}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;

if sf == '0' && imm6<5> == '1' then UNDEFINED;

ShiftType shift_type = DecodeShift(shift);
integer shift_amount = UInt(imm6);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.

<shift> Is the optional shift to be applied to the final source, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	ROR

<amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.  
For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field,

## Alias Conditions

Alias	Is preferred when
<a href="#">TST (shifted register)</a>	Rd == '11111'

## Operation

```
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = ShiftReg(m, shift_type, shift_amount);

result = operand1 AND operand2;
PSTATE.<N,Z,C,V> = result<datasize-1>:IsZeroBit(result):'00';

X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.







## ASR (immediate)

Arithmetic Shift Right (immediate) shifts a register value right by an immediate number of bits, shifting in copies of the sign bit in the upper bits and zeros in the lower bits, and writes the result to the destination register.

This is an alias of [SBFM](#). This means:

- The encodings in this description are named to match the encodings of [SBFM](#).
- The description of [SBFM](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	0	1	0	0	1	1	0	N	immr						x	1	1	1	1	1	Rn						Rd			
opc										imms																					

### 32-bit (sf == 0 && N == 0 && imms == 011111)

ASR <Wd>, <Wn>, #<shift>

is equivalent to

[SBFM](#) <Wd>, <Wn>, #<shift>, #31

and is always the preferred disassembly.

### 64-bit (sf == 1 && N == 1 && imms == 111111)

ASR <Xd>, <Xn>, #<shift>

is equivalent to

[SBFM](#) <Xd>, <Xn>, #<shift>, #63

and is always the preferred disassembly.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
<shift>	For the 32-bit variant: is the shift amount, in the range 0 to 31, encoded in the "immr" field. For the 64-bit variant: is the shift amount, in the range 0 to 63, encoded in the "immr" field.

## Operation

The description of [SBFM](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## ASRV

Arithmetic Shift Right Variable shifts a register value right by a variable number of bits, shifting in copies of its sign bit, and writes the result to the destination register. The remainder obtained by dividing the second source register by the data size defines the number of bits by which the first source register is right-shifted.

This instruction is used by the alias [ASR \(register\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0								
sf	0	0	1	1	0	1	0	1	1	0	Rm					0	0	1	0	1	0	Rn					Rd												
																					op2																		

### 32-bit (sf == 0)

ASRV <Wd>, <Wn>, <Wm>

### 64-bit (sf == 1)

ASRV <Xd>, <Xn>, <Xm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
ShiftType shift_type = DecodeShift(op2);
```

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Wm>	Is the 32-bit name of the second general-purpose source register holding a shift amount from 0 to 31 in its bottom 5 bits, encoded in the "Rm" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the second general-purpose source register holding a shift amount from 0 to 63 in its bottom 6 bits, encoded in the "Rm" field.

## Operation

```
bits(datasize) result;
bits(datasize) operand2 = X[m];

result = ShiftReg(n, shift_type, UInt(operand2) MOD datasize);
X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

AT

Address Translate. For more information, see *op0==0b01, cache maintenance, TLB maintenance, and address translation instructions*.

This is an alias of [SYS](#). This means:

- The encodings in this description are named to match the encodings of [SYS](#).
- The description of [SYS](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	1	op1			0	1	1	1	1	0	0	x	op2			Rt				
L											CRn					CRm															

AT [<at\\_op>](#), [<Xt>](#)

is equivalent to

[SYS](#) [#<op1>](#), C7, [<Cm>](#), [#<op2>](#), [<Xt>](#)

and is the preferred disassembly when `SysOp(op1, '0111', CRm, op2) == Sys_AT`.

Assembler Symbols

[<at\\_op>](#) Is an AT instruction name, as listed for the AT system instruction group, encoded in "op1:CRm<0>:op2":

op1	CRm<0>	op2	<at_op>	Architectural Feature
000	0	000	S1E1R	-
000	0	001	S1E1W	-
000	0	010	S1E0R	-
000	0	011	S1E0W	-
000	1	000	S1E1RP	FEAT_PAN2
000	1	001	S1E1WP	FEAT_PAN2
100	0	000	S1E2R	-
100	0	001	S1E2W	-
100	0	100	S12E1R	-
100	0	101	S12E1W	-
100	0	110	S12E0R	-
100	0	111	S12E0W	-
110	0	000	S1E3R	-
110	0	001	S1E3W	-

[<op1>](#) Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the "op1" field.

[<Cm>](#) Is a name 'Cm', with 'm' in the range 0 to 15, encoded in the "CRm" field.

[<op2>](#) Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the "op2" field.

[<Xt>](#) Is the 64-bit name of the general-purpose source register, encoded in the "Rt" field.

Operation

The description of [SYS](#) gives the operational pseudocode for this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# AUTDA, AUTDZA

Authenticate Data address, using key A. This instruction authenticates a data address, using a modifier and key A. The address is in the general-purpose register that is specified by <Xd>. The modifier is:

- In the general-purpose register or stack pointer that is specified by <Xn|SP> for AUTDA.
- The value zero, for AUTDZA.

If the authentication passes, the upper bits of the address are restored to enable subsequent use of the address. If the authentication fails, the upper bits are corrupted and any subsequent use of the address results in a Translation fault.

## Integer (FEAT\_PAuth)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	1	0	1	1	0	0	0	0	0	1	0	0	Z	1	1	0	Rn					Rd				

### AUTDA (Z == 0)

AUTDA <Xd>, <Xn|SP>

### AUTDZA (Z == 1 && Rn == 11111)

AUTDZA <Xd>

```
boolean source_is_sp = FALSE;
integer d = UInt(Rd);
integer n = UInt(Rn);

if !HavePACExt() then
    UNDEFINED;

if Z == '0' then // AUTDA
    if n == 31 then source_is_sp = TRUE;
else // AUTDZA
    if n != 31 then UNDEFINED;
```

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn|SP> Is the 64-bit name of the general-purpose source register or stack pointer, encoded in the "Rn" field.

## Operation

```
if HavePACExt() then
    if source_is_sp then
        X[d] = AuthDA(X[d], SP[], FALSE);
    else
        X[d] = AuthDA(X[d], X[n], FALSE);
```

## AUTDB, AUTDZB

Authenticate Data address, using key B. This instruction authenticates a data address, using a modifier and key B. The address is in the general-purpose register that is specified by <Xd>.

The modifier is:

- In the general-purpose register or stack pointer that is specified by <Xn|SP> for AUTDB.
- The value zero, for AUTDZB.

If the authentication passes, the upper bits of the address are restored to enable subsequent use of the address. If the authentication fails, the upper bits are corrupted and any subsequent use of the address results in a Translation fault.

### Integer

(FEAT\_PAuth)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	1	0	1	1	0	0	0	0	1	0	0	Z	1	1	1	Rn					Rd					

### AUTDB (Z == 0)

AUTDB <Xd>, <Xn|SP>

### AUTDZB (Z == 1 && Rn == 11111)

AUTDZB <Xd>

```
boolean source_is_sp = FALSE;
integer d = UInt(Rd);
integer n = UInt(Rn);

if !HavePACExt() then
    UNDEFINED;

if Z == '0' then // AUTDB
    if n == 31 then source_is_sp = TRUE;
else // AUTDZB
    if n != 31 then UNDEFINED;
```

### Assembler Symbols

<Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.

<Xn|SP> Is the 64-bit name of the general-purpose source register or stack pointer, encoded in the "Rn" field.

### Operation

```
if HavePACExt() then
    if source_is_sp then
        X[d] = AuthDB(X[d], SP[], FALSE);
    else
        X[d] = AuthDB(X[d], X[n], FALSE);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# AUTIA, AUTIA1716, AUTIASP, AUTIAZ, AUTIZA

Authenticate Instruction address, using key A. This instruction authenticates an instruction address, using a modifier and key A.

The address is:

- In the general-purpose register that is specified by <Xd> for AUTIA and AUTIZA.
- In X17, for AUTIA1716.
- In X30, for AUTIASP and AUTIAZ.

The modifier is:

- In the general-purpose register or stack pointer that is specified by <Xn|SP> for AUTIA.
- The value zero, for AUTIZA and AUTIAZ.
- In X16, for AUTIA1716.
- In SP, for AUTIASP.

If the authentication passes, the upper bits of the address are restored to enable subsequent use of the address. If the authentication fails, the upper bits are corrupted and any subsequent use of the address results in a Translation fault.

It has encodings from 2 classes: [Integer](#) and [System](#)

## Integer

(FEAT\_PAuth)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	1	0	1	1	0	0	0	0	0	1	0	0	Z	1	0	0	Rn				Rd					

## AUTIA (Z == 0)

AUTIA <Xd>, <Xn|SP>

## AUTIZA (Z == 1 && Rn == 11111)

AUTIZA <Xd>

```
boolean source_is_sp = FALSE;
integer d = UInt(Rd);
integer n = UInt(Rn);

if !HavePACExt() then
    UNDEFINED;

if Z == '0' then // AUTIA
    if n == 31 then source_is_sp = TRUE;
else // AUTIZA
    if n != 31 then UNDEFINED;
```

## System

(FEAT\_PAuth)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	x	1	1	0	x	1	1	1	1	1
												CRm				op2															

## AUTIA1716 (CRm == 0001 && op2 == 100)

AUTIA1716

## AUTIASP (CRm == 0011 && op2 == 101)

AUTIASP

## AUTIAZ (CRm == 0011 && op2 == 100)

AUTIAZ

```
integer d;  
integer n;  
boolean source_is_sp = FALSE;  
  
case CRm:op2 of  
  when '0011 100'    // AUTIAZ  
    d = 30;  
    n = 31;  
  when '0011 101'    // AUTIASP  
    d = 30;  
    source_is_sp = TRUE;  
  when '0001 100'    // AUTIA1716  
    d = 17;  
    n = 16;  
  when '0001 000' SEE "PACIA";  
  when '0001 010' SEE "PACIB";  
  when '0001 110' SEE "AUTIB";  
  when '0011 00x' SEE "PACIA";  
  when '0011 01x' SEE "PACIB";  
  when '0011 11x' SEE "AUTIB";  
  when '0000 111' SEE "XPACLRI";  
  otherwise SEE "HINT";
```

## Assembler Symbols

<Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.

<Xn|SP> Is the 64-bit name of the general-purpose source register or stack pointer, encoded in the "Rn" field.

## Operation

```
if HavePACExt() then  
  if source_is_sp then  
    X[d] = AuthIA(X[d], SP[], FALSE);  
  else  
    X[d] = AuthIA(X[d], X[n], FALSE);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# AUTIB, AUTIB1716, AUTIBSP, AUTIBZ, AUTIZB

Authenticate Instruction address, using key B. This instruction authenticates an instruction address, using a modifier and key B.

The address is:

- In the general-purpose register that is specified by <Xd> for AUTIB and AUTIZB.
- In X17, for AUTIB1716.
- In X30, for AUTIBSP and AUTIBZ.

The modifier is:

- In the general-purpose register or stack pointer that is specified by <Xn|SP> for AUTIB.
- The value zero, for AUTIZB and AUTIBZ.
- In X16, for AUTIB1716.
- In SP, for AUTIBSP.

If the authentication passes, the upper bits of the address are restored to enable subsequent use of the address. If the authentication fails, the upper bits are corrupted and any subsequent use of the address results in a Translation fault.

It has encodings from 2 classes: [Integer](#) and [System](#)

## Integer

(FEAT\_PAuth)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	1	0	1	1	0	0	0	0	0	1	0	0	Z	1	0	1	Rn				Rd					

## AUTIB (Z == 0)

AUTIB <Xd>, <Xn|SP>

## AUTIZB (Z == 1 && Rn == 11111)

AUTIZB <Xd>

```
boolean source_is_sp = FALSE;
integer d = UInt(Rd);
integer n = UInt(Rn);

if !HavePACExt() then
    UNDEFINED;

if Z == '0' then // AUTIB
    if n == 31 then source_is_sp = TRUE;
else // AUTIZB
    if n != 31 then UNDEFINED;
```

## System

(FEAT\_PAuth)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0					
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	x	1	1	1	x	1	1	1	1	1					
																					CRm				op2											

## AUTIB1716 (CRm == 0001 && op2 == 110)

AUTIB1716

## AUTIBSP (CRm == 0011 && op2 == 111)

AUTIBSP

## AUTIBZ (CRm == 0011 && op2 == 110)

AUTIBZ

```
integer d;  
integer n;  
boolean source_is_sp = FALSE;  
  
case CRm:op2 of  
  when '0011 110'    // AUTIBZ  
    d = 30;  
    n = 31;  
  when '0011 111'    // AUTIBSP  
    d = 30;  
    source_is_sp = TRUE;  
  when '0001 110'    // AUTIB1716  
    d = 17;  
    n = 16;  
  when '0001 000' SEE "PACIA";  
  when '0001 010' SEE "PACIB";  
  when '0001 100' SEE "AUTIA";  
  when '0011 00x' SEE "PACIA";  
  when '0011 01x' SEE "PACIB";  
  when '0011 10x' SEE "AUTIA";  
  when '0000 111' SEE "XPACLRI";  
  otherwise SEE "HINT";
```

## Assembler Symbols

<Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.

<Xn|SP> Is the 64-bit name of the general-purpose source register or stack pointer, encoded in the "Rn" field.

## Operation

```
if HavePACExt() then  
  if source_is_sp then  
    X[d] = AuthIB(X[d], SP[], FALSE);  
  else  
    X[d] = AuthIB(X[d], X[n], FALSE);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# AXFLAG

Convert floating-point condition flags from Arm to external format. This instruction converts the state of the PSTATE.{N,Z,C,V} flags from a form representing the result of an Arm floating-point scalar compare instruction to an alternative representation required by some software.

## System (FEAT\_FlagM2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	(0)	(0)	(0)	(0)	0	1	0	1	1	1	1	1

CRm

## AXFLAG

if !HaveFlagFormatExt() then UNDEFINED;

## Operation

```
bit Z = PSTATE.Z OR PSTATE.V;  
bit C = PSTATE.C AND NOT(PSTATE.V);  
  
PSTATE.N = '0';  
PSTATE.Z = Z;  
PSTATE.C = C;  
PSTATE.V = '0';
```

# B.cond

Branch conditionally to a label at a PC-relative offset, with a hint that this is not a subroutine call or return.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	0	1	0	0	imm19																		0	cond				

B.<cond> <label>

```
bits(64) offset = SignExtend(imm19:'00', 64);
```

## Assembler Symbols

- <cond> Is one of the standard conditions, encoded in the "cond" field in the standard way.
- <label> Is the program label to be conditionally branched to. Its offset from the address of this instruction, in the range +/-1MB, is encoded as "imm19" times 4.

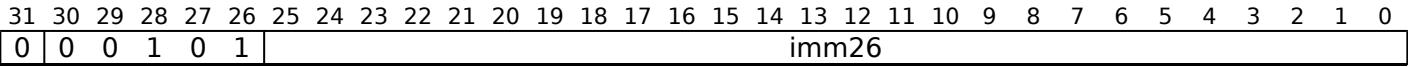
## Operation

```
if ConditionHolds(cond) then
    BranchTo(PC[] + offset, BranchType_DIR, TRUE);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41  
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

B

Branch causes an unconditional branch to a label at a PC-relative offset, with a hint that this is not a subroutine call or return.



op

B <label>

```
bits(64) offset = SignExtend(imm26:'00', 64);
```

Assembler Symbols

<label> Is the program label to be unconditionally branched to. Its offset from the address of this instruction, in the range +/-128MB, is encoded as "imm26" times 4.

Operation

```
BranchTo(PC[] + offset, BranchType_DIR, FALSE);
```

# BFC

Bitfield Clear sets a bitfield of <width> bits at bit position <lsb> of the destination register to zero, leaving the other destination bits unchanged.

This is an alias of [BFM](#). This means:

- The encodings in this description are named to match the encodings of [BFM](#).
- The description of [BFM](#) gives the operational pseudocode for this instruction.

## Leaving other bits unchanged (FEAT\_ASMv8p2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
sf	0	1	1	0	0	1	1	0	N	immr						imms						1	1	1	1	1	Rd					
opc										Rn																						

### 32-bit (sf == 0 && N == 0)

BFC <Wd>, #<lsb>, #<width>

is equivalent to

[BFM](#) <Wd>, WZR, #(-<lsb> MOD 32), #(<width>-1)

and is the preferred disassembly when `UInt(imms) < UInt(immr)`.

### 64-bit (sf == 1 && N == 1)

BFC <Xd>, #<lsb>, #<width>

is equivalent to

[BFM](#) <Xd>, XZR, #(-<lsb> MOD 64), #(<width>-1)

and is the preferred disassembly when `UInt(imms) < UInt(immr)`.

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <lsb> For the 32-bit variant: is the bit number of the lsb of the destination bitfield, in the range 0 to 31.  
For the 64-bit variant: is the bit number of the lsb of the destination bitfield, in the range 0 to 63.
- <width> For the 32-bit variant: is the width of the bitfield, in the range 1 to 32-<lsb>.  
For the 64-bit variant: is the width of the bitfield, in the range 1 to 64-<lsb>.

## Operation

The description of [BFM](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.



## BFI

Bitfield Insert copies a bitfield of <width> bits from the least significant bits of the source register to bit position <lsb> of the destination register, leaving the other destination bits unchanged.

This is an alias of [BFM](#). This means:

- The encodings in this description are named to match the encodings of [BFM](#).
- The description of [BFM](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	1	1	0	0	1	1	0	N	immr						imms						!= 1111				Rd					
opc										Rn																					

### 32-bit (sf == 0 && N == 0)

BFI <Wd>, <Wn>, #<lsb>, #<width>

is equivalent to

BFM <Wd>, <Wn>, #(-<lsb> MOD 32), #(<width>-1)

and is the preferred disassembly when `UInt(imms) < UInt(immr)`.

### 64-bit (sf == 1 && N == 1)

BFI <Xd>, <Xn>, #<lsb>, #<width>

is equivalent to

BFM <Xd>, <Xn>, #(-<lsb> MOD 64), #(<width>-1)

and is the preferred disassembly when `UInt(imms) < UInt(immr)`.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
<lsb>	For the 32-bit variant: is the bit number of the lsb of the destination bitfield, in the range 0 to 31. For the 64-bit variant: is the bit number of the lsb of the destination bitfield, in the range 0 to 63.
<width>	For the 32-bit variant: is the width of the bitfield, in the range 1 to 32-<lsb>. For the 64-bit variant: is the width of the bitfield, in the range 1 to 64-<lsb>.

## Operation

The description of [BFM](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.





BFM

Bitfield Move is usually accessed via one of its aliases, which are always preferred for disassembly.

If `<imms>` is greater than or equal to `<immr>`, this copies a bitfield of (`<imms>-<immr>+1`) bits starting from bit position `<immr>` in the source register to the least significant bits of the destination register.

If `<imms>` is less than `<immr>`, this copies a bitfield of (`<imms>+1`) bits from the least significant bits of the source register to bit position (`regsize-<immr>`) of the destination register, where `regsize` is the destination register size of 32 or 64 bits.

In both cases the other bits of the destination register remain unchanged.

This instruction is used by the aliases [BFC](#), [BFI](#), and [BFXIL](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	1	1	0	0	1	1	0	N	immr					imms					Rn					Rd						
opc																															

32-bit (sf == 0 && N == 0)

BFM `<Wd>`, `<Wn>`, `#<immr>`, `#<imms>`

64-bit (sf == 1 && N == 1)

BFM `<Xd>`, `<Xn>`, `#<immr>`, `#<imms>`

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer datasize = if sf == '1' then 64 else 32;

integer R;
bits(datasize) wmask;
bits(datasize) tmask;

if sf == '1' && N != '1' then UNDEFINED;
if sf == '0' && (N != '0' || immr<5> != '0' || imms<5> != '0') then UNDEFINED;

R = UInt(immr);
(wmask, tmask) = DecodeBitMasks(N, imms, immr, FALSE);
```

Assembler Symbols

- `<Wd>` Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- `<Wn>` Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
- `<Xd>` Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- `<Xn>` Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
- `<immr>` For the 32-bit variant: is the right rotate amount, in the range 0 to 31, encoded in the "immr" field.  
For the 64-bit variant: is the right rotate amount, in the range 0 to 63, encoded in the "immr" field.
- `<imms>` For the 32-bit variant: is the leftmost bit number to be moved from the source, in the range 0 to 31, encoded in the "imms" field.  
For the 64-bit variant: is the leftmost bit number to be moved from the source, in the range 0 to 63, encoded in the "imms" field.

Alias Conditions

Alias	Is preferred when
<a href="#">BFC</a>	<code>Rn == '11111' &amp;&amp; UInt(imms) &lt; UInt(immr)</code>
<a href="#">BFI</a>	<code>Rn != '11111' &amp;&amp; UInt(imms) &lt; UInt(immr)</code>
<a href="#">BFXIL</a>	<code>UInt(imms) &gt;= UInt(immr)</code>

## Operation

```
bits(datasize) dst = X[d];
bits(datasize) src = X[n];

// perform bitfield move on low bits
bits(datasize) bot = (dst AND NOT(wmask)) OR (ROR(src, R) AND wmask);

// combine extension bits and result bits
X[d] = (dst AND NOT(tmask)) OR (bot AND tmask);
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## BFXIL

Bitfield Extract and Insert Low copies a bitfield of <width> bits starting from bit position <lsb> in the source register to the least significant bits of the destination register, leaving the other destination bits unchanged.

This is an alias of [BFM](#). This means:

- The encodings in this description are named to match the encodings of [BFM](#).
- The description of [BFM](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	1	1	0	0	1	1	0	N	immr						imms						Rn						Rd			
opc																															

### 32-bit (sf == 0 && N == 0)

BFXIL <Wd>, <Wn>, #<lsb>, #<width>

is equivalent to

BFM <Wd>, <Wn>, #<lsb>, #(<lsb>+<width>-1)

and is the preferred disassembly when `UInt(imms) >= UInt(immr)`.

### 64-bit (sf == 1 && N == 1)

BFXIL <Xd>, <Xn>, #<lsb>, #<width>

is equivalent to

BFM <Xd>, <Xn>, #<lsb>, #(<lsb>+<width>-1)

and is the preferred disassembly when `UInt(imms) >= UInt(immr)`.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
<lsb>	For the 32-bit variant: is the bit number of the lsb of the source bitfield, in the range 0 to 31. For the 64-bit variant: is the bit number of the lsb of the source bitfield, in the range 0 to 63.
<width>	For the 32-bit variant: is the width of the bitfield, in the range 1 to 32-<lsb>. For the 64-bit variant: is the width of the bitfield, in the range 1 to 64-<lsb>.

## Operation

The description of [BFM](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.



# BIC (shifted register)

Bitwise Bit Clear (shifted register) performs a bitwise AND of a register value and the complement of an optionally-shifted register value, and writes the result to the destination register.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	0	0	1	0	1	0	shift	1	Rm						imm6						Rn						Rd			
opc								N																							

## 32-bit (sf == 0)

BIC <Wd>, <Wn>, <Wm>{, <shift> #<amount>}

## 64-bit (sf == 1)

BIC <Xd>, <Xn>, <Xm>{, <shift> #<amount>}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
if sf == '0' && imm6<5> == '1' then UNDEFINED;

ShiftType shift_type = DecodeShift(shift);
integer shift_amount = UInt(imm6);
```

## Assembler Symbols

- <Wd>

Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn>

Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm>

Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd>

Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn>

Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm>

Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <shift>

Is the optional shift to be applied to the final source, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	ROR
- <amount>

For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.  
  
For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field,

## Operation

```
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = ShiftReg(m, shift_type, shift_amount);

operand2 = NOT(operand2);

result = operand1 AND operand2;
X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

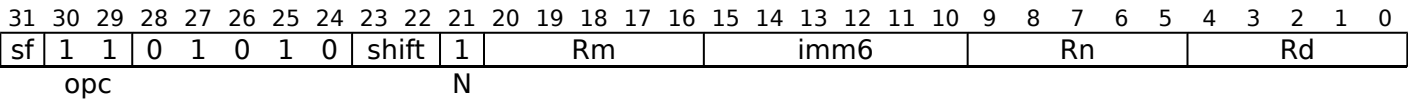
- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## BICS (shifted register)

Bitwise Bit Clear (shifted register), setting flags, performs a bitwise AND of a register value and the complement of an optionally-shifted register value, and writes the result to the destination register. It updates the condition flags based on the result.



### 32-bit (sf == 0)

BICS <Wd>, <Wn>, <Wm>{, <shift> #<amount>}

### 64-bit (sf == 1)

BICS <Xd>, <Xn>, <Xm>{, <shift> #<amount>}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;

if sf == '0' && imm6<5> == '1' then UNDEFINED;

ShiftType shift_type = DecodeShift(shift);
integer shift_amount = UInt(imm6);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.

<shift> Is the optional shift to be applied to the final source, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	ROR

<amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.  
For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field,



## Operation

```
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = ShiftReg(m, shift_type, shift_amount);

operand2 = NOT(operand2);

result = operand1 AND operand2;
PSTATE.<N,Z,C,V> = result<datasize-1>:IsZeroBit(result):'00';

X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

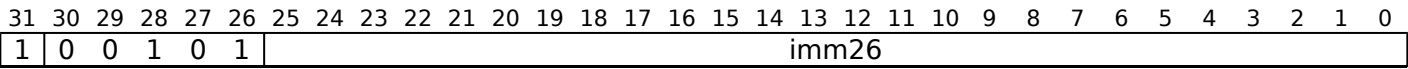
- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

BL

Branch with Link branches to a PC-relative offset, setting the register X30 to PC+4. It provides a hint that this is a subroutine call.



op

BL <label>

```
bits(64) offset = SignExtend(imm26:'00', 64);
```

Assembler Symbols

<label> Is the program label to be unconditionally branched to. Its offset from the address of this instruction, in the range +/-128MB, is encoded as "imm26" times 4.

Operation

```
X[30] = PC[] + 4;
BranchTo(PC[] + offset, BranchType_DIRCALL, FALSE);
```

BLR

Branch with Link to Register calls a subroutine at an address in a register, setting register X30 to PC+4.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0							
1	1	0	1	0	1	1	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0																	
							Z	op								A	M					Rn																

BLR <Xn>

```
integer n = UInt(Rn);
```

Assembler Symbols

<Xn> Is the 64-bit name of the general-purpose register holding the address to be branched to, encoded in the "Rn" field.

Operation

```
bits(64) target = X[n];
X[30] = PC[] + 4;
// Value in BTypeNext will be used to set PSTATE.BTYPE
BTypeNext = '10';
BranchTo(target, BranchType_INDCALL, FALSE);
```

# BLRAA, BLRAAZ, BLRAB, BLRABZ

Branch with Link to Register, with pointer authentication. This instruction authenticates the address in the general-purpose register that is specified by <Xn>, using a modifier and the specified key, and calls a subroutine at the authenticated address, setting register X30 to PC+4.

The modifier is:

- In the general-purpose register or stack pointer that is specified by <Xm|SP> for BLRAA and BLRAB.
- The value zero, for BLRAAZ and BLRABZ.

Key A is used for BLRAA and BLRAAZ, and key B is used for BLRAB and BLRABZ.

If the authentication passes, the PE continues execution at the target of the branch. If the authentication fails, a Translation fault is generated.

The authenticated address is not written back to the general-purpose register.

## Integer

(FEAT\_PAuth)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	1	Z	0	0	1	1	1	1	1	0	0	0	0	1	M	Rn				Rm						
op																A															

Key A, zero modifier (Z == 0 && M == 0 && Rm == 11111)

BLRAAZ <Xn>

Key A, register modifier (Z == 1 && M == 0)

BLRAA <Xn>, <Xm|SP>

Key B, zero modifier (Z == 0 && M == 1 && Rm == 11111)

BLRABZ <Xn>

Key B, register modifier (Z == 1 && M == 1)

BLRAB <Xn>, <Xm|SP>

```
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean use_key_a = (M == '0');
boolean source_is_sp = ((Z == '1') && (m == 31));

if !HavePACExt() then
    UNDEFINED;

if Z == '0' && m != 31 then
    UNDEFINED;
```

## Assembler Symbols

- <Xn>
- Is the 64-bit name of the general-purpose register holding the address to be branched to, encoded in the "Rn" field.
- <Xm|SP>
- Is the 64-bit name of the general-purpose source register or stack pointer holding the modifier, encoded in the "Rm" field.

## Operation

```
bits(64) target = X[n];
bits(64) modifier = if source_is_sp then SP[] else X[m];
if use_key_a then
    target = AuthIA(target, modifier, TRUE);
else
    target = AuthIB(target, modifier, TRUE);
X[30] = PC[] + 4;

// Value in BTypeNext will be used to set PSTATE.BTYPE
BTypeNext = '10';
BranchTo(target, BranchType_INDCALL, FALSE);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# BRAA, BRAAZ, BRAB, BRABZ

Branch to Register, with pointer authentication. This instruction authenticates the address in the general-purpose register that is specified by <Xn>, using a modifier and the specified key, and branches to the authenticated address. The modifier is:

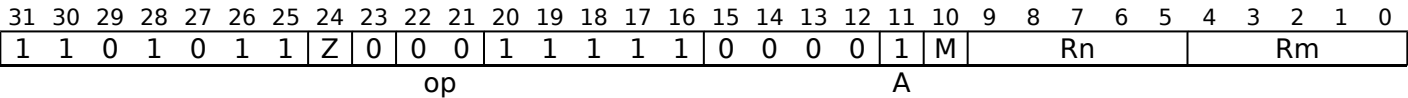
- In the general-purpose register or stack pointer that is specified by <Xm|SP> for BRAA and BRAB.
- The value zero, for BRAAZ and BRABZ.

Key A is used for BRAA and BRAAZ, and key B is used for BRAB and BRABZ.

If the authentication passes, the PE continues execution at the target of the branch. If the authentication fails, a Translation fault is generated.

The authenticated address is not written back to the general-purpose register.

## Integer (FEAT\_PAuth)



### Key A, zero modifier (Z == 0 && M == 0 && Rm == 11111)

BRAAZ <Xn>

### Key A, register modifier (Z == 1 && M == 0)

BRAA <Xn>, <Xm|SP>

### Key B, zero modifier (Z == 0 && M == 1 && Rm == 11111)

BRABZ <Xn>

### Key B, register modifier (Z == 1 && M == 1)

BRAB <Xn>, <Xm|SP>

```
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean use_key_a = (M == '0');
boolean source_is_sp = ((Z == '1') && (m == 31));

if !HavePACExt() then
    UNDEFINED;

if Z == '0' && m != 31 then
    UNDEFINED;
```

## Assembler Symbols

- <Xn>
- Is the 64-bit name of the general-purpose register holding the address to be branched to, encoded in the "Rn" field.
- <Xm|SP>
- Is the 64-bit name of the general-purpose source register or stack pointer holding the modifier, encoded in the "Rm" field.

## Operation

```
bits(64) target = X[n];
bits(64) modifier = if source_is_sp then SP[] else X[m];
if use_key_a then
    target = AuthIA(target, modifier, TRUE);
else
    target = AuthIB(target, modifier, TRUE);

// Value in BTypeNext will be used to set PSTATE.BTYPE
if InGuardedPage then
    if n == 16 || n == 17 then
        BTypeNext = '01';
    else
        BTypeNext = '11';
else
    BTypeNext = '01';
BranchTo(target, BranchType_INDIR, FALSE);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# BRK

Breakpoint instruction. A BRK instruction generates a Breakpoint Instruction exception. The PE records the exception in *ESR\_ELx*, using the EC value 0x3c, and captures the value of the immediate argument in *ESR\_ELx*.ISS.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	0	0	0	1	imm16																0	0	0	0	0

BRK #<imm>

```
if HaveBTIExt() then
    SetBTypeCompatible(TRUE);
```

## Assembler Symbols

<imm> Is a 16-bit unsigned immediate, in the range 0 to 65535, encoded in the "imm16" field.

## Operation

```
AArch64.SoftwareBreakpoint(imm16);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41  
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

BTI

Branch Target Identification. A BTI instruction is used to guard against the execution of instructions which are not the intended target of a branch.

Outside of a guarded memory region, a BTI instruction executes as a NOP. Within a guarded memory region while *PSTATE*.BTTYPE != 0b00, a BTI instruction compatible with the current value of *PSTATE*.BTTYPE will not generate a Branch Target Exception and will allow execution of subsequent instructions within the memory region.

The operand <targets> passed to a BTI instruction determines the values of *PSTATE*.BTTYPE which the BTI instruction is compatible with.

Within a guarded memory region, when *PSTATE*.BTTYPE != 0b00, all instructions will generate a Branch Target Exception, other than BRK, BTI, HLT, PACIASP, and PACIBSP, which might not. See the individual instructions for more information.

System  
(FEAT\_BTI)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	1	0	0	x	x	0	1	1	1	1	1
																CRm				op2											

BTI {<targets>}

```
SystemHintOp op;  
  
if CRm:op2 == '0100 xx0' then  
    op = SystemHintOp_BTI;  
    // Check branch target compatibility between BTI instruction and PSTATE.BTTYPE  
    SetBTypeCompatible(BTypeCompatible_BTI(op2<2:1>));  
else  
    EndOfInstruction();
```

Assembler Symbols

<targets> Is the type of indirection, encoded in “op2<2:1>”:

op2<2:1>	<targets>
00	(omitted)
01	c
10	j
11	jc

## Operation

```
case op of
  when SystemHintOp\_YIELD
    Hint\_Yield\(\);

  when SystemHintOp\_DGH
    Hint\_DGH\(\);

  when SystemHintOp\_WFE
    Hint\_WFE(-1, WFXType\_WFE);

  when SystemHintOp\_WFI
    Hint\_WFI(-1, WFXType\_WFI);

  when SystemHintOp\_SEV
    SendEvent\(\);

  when SystemHintOp\_SEVL
    SendEventLocal\(\);

  when SystemHintOp\_ESB
    SynchronizeErrors\(\);
    AArch64.ESB0operation\(\);
    if PSTATE.EL IN {EL0, EL1} && EL2Enabled\(\) then AArch64.vESB0operation\(\);
    TakeUnmaskedSErrorInterrupts\(\);

  when SystemHintOp\_PSB
    ProfilingSynchronizationBarrier\(\);

  when SystemHintOp\_TSB
    TraceSynchronizationBarrier\(\);

  when SystemHintOp\_CSDb
    ConsumptionOfSpeculativeDataBarrier\(\);

  when SystemHintOp\_BTI
    SetBTypeNext('00');

  otherwise // do nothing
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# CAS, CASA, CASAL, CASL

Compare and Swap word or doubleword in memory reads a 32-bit word or 64-bit doubleword from memory, and compares it against the value held in a first register. If the comparison is equal, the value in a second register is written to memory. If the write is performed, the read and write occur atomically such that no other modification of the memory location can take place between the read and write.

- CASA and CASAL load from memory with acquire semantics.
- CASL and CASAL store to memory with release semantics.
- CAS has neither acquire nor release semantics.

For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

The architecture permits that the data read clears any exclusive monitors associated with that location, even if the compare subsequently fails.

If the instruction generates a synchronous Data Abort, the register which is compared and loaded, that is <Ws>, or <Xs>, is restored to the value held in the register before the instruction was executed.

## No offset (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	0	0	1	0	0	0	1	L	1	Rs				o0	1	1	1	1	1	Rn				Rt						
size																															

### 32-bit CAS (size == 10 && L == 0 && o0 == 0)

CAS <Ws>, <Wt>, [<Xn|SP>{,#0}]

### 32-bit CASA (size == 10 && L == 1 && o0 == 0)

CASA <Ws>, <Wt>, [<Xn|SP>{,#0}]

### 32-bit CASAL (size == 10 && L == 1 && o0 == 1)

CASAL <Ws>, <Wt>, [<Xn|SP>{,#0}]

### 32-bit CASL (size == 10 && L == 0 && o0 == 1)

CASL <Ws>, <Wt>, [<Xn|SP>{,#0}]

### 64-bit CAS (size == 11 && L == 0 && o0 == 0)

CAS <Xs>, <Xt>, [<Xn|SP>{,#0}]

### 64-bit CASA (size == 11 && L == 1 && o0 == 0)

CASA <Xs>, <Xt>, [<Xn|SP>{,#0}]

### 64-bit CASAL (size == 11 && L == 1 && o0 == 1)

CASAL <Xs>, <Xt>, [<Xn|SP>{,#0}]

### 64-bit CASL (size == 11 && L == 0 && o0 == 1)

CASL <Xs>, <Xt>, [<Xn|SP>{,#0}]

```
if !HaveAtomicExt() then UNDEFINED;

integer n = UInt(Rn);
integer t = UInt(Rt);
integer s = UInt(Rs);

integer datasize = 8 << UInt(size);
integer regsize = if datasize == 64 then 64 else 32;
AccType ldacctype = if L == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if o0 == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

<Ws>	Is the 32-bit name of the general-purpose register to be compared and loaded, encoded in the "Rs" field.
<Wt>	Is the 32-bit name of the general-purpose register to be conditionally stored, encoded in the "Rt" field.
<Xs>	Is the 64-bit name of the general-purpose register to be compared and loaded, encoded in the "Rs" field.
<Xt>	Is the 64-bit name of the general-purpose register to be conditionally stored, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(datasize) comparevalue;
bits(datasize) newvalue;
bits(datasize) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

comparevalue = X[s];
newvalue = X[t];

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomicCompareAndSwap(address, comparevalue, newvalue, ldacctype, stacctype);
X[s] = ZeroExtend(data, regsize);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## CASB, CASAB, CASALB, CASLB

Compare and Swap byte in memory reads an 8-bit byte from memory, and compares it against the value held in a first register. If the comparison is equal, the value in a second register is written to memory. If the write is performed, the read and write occur atomically such that no other modification of the memory location can take place between the read and write.

- CASAB and CASALB load from memory with acquire semantics.
- CASLB and CASALB store to memory with release semantics.
- CASB has neither acquire nor release semantics.

For more information about memory ordering semantics see [Load-Acquire, Store-Release](#).

For information about memory accesses see [Load/Store addressing modes](#).

The architecture permits that the data read clears any exclusive monitors associated with that location, even if the compare subsequently fails.

If the instruction generates a synchronous Data Abort, the register which is compared and loaded, that is <Ws>, is restored to the values held in the register before the instruction was executed.

### No offset

(FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	1	0	0	0	1	L	1	Rs				o0		1	1	1	1	1	Rn				Rt					
size																															

### CASAB (L == 1 && o0 == 0)

CASAB <Ws>, <Wt>, [<Xn|SP>{, #0}]

### CASALB (L == 1 && o0 == 1)

CASALB <Ws>, <Wt>, [<Xn|SP>{, #0}]

### CASB (L == 0 && o0 == 0)

CASB <Ws>, <Wt>, [<Xn|SP>{, #0}]

### CASLB (L == 0 && o0 == 1)

CASLB <Ws>, <Wt>, [<Xn|SP>{, #0}]

```
if !HaveAtomicExt() then UNDEFINED;
```

```
integer n = UInt(Rn);  
integer t = UInt(Rt);  
integer s = UInt(Rs);
```

```
AccType ldacctype = if L == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;  
AccType stacctype = if o0 == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;  
boolean tag_checked = n != 31;
```

## Assembler Symbols

<Ws>	Is the 32-bit name of the general-purpose register to be compared and loaded, encoded in the "Rs" field.
<Wt>	Is the 32-bit name of the general-purpose register to be conditionally stored, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(8) comparevalue;
bits(8) newvalue;
bits(8) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

comparevalue = X[s];
newvalue = X[t];

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomicCompareAndSwap(address, comparevalue, newvalue, ldacctype, stacctype);
X[s] = ZeroExtend(data, 32);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# CASH, CASAH, CASALH, CASLH

Compare and Swap halfword in memory reads a 16-bit halfword from memory, and compares it against the value held in a first register. If the comparison is equal, the value in a second register is written to memory. If the write is performed, the read and write occur atomically such that no other modification of the memory location can take place between the read and write.

- CASAH and CASALH load from memory with acquire semantics.
- CASLH and CASALH store to memory with release semantics.
- CAS has neither acquire nor release semantics.

For more information about memory ordering semantics see [Load-Acquire, Store-Release](#).

For information about memory accesses see [Load/Store addressing modes](#).

The architecture permits that the data read clears any exclusive monitors associated with that location, even if the compare subsequently fails.

If the instruction generates a synchronous Data Abort, the register which is compared and loaded, that is <Ws>, is restored to the values held in the register before the instruction was executed.

## No offset (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	1	0	0	0	1	L	1	Rs				o0	1	1	1	1	1	Rn				Rt						
size																															

## CASAH (L == 1 && o0 == 0)

CASAH <Ws>, <Wt>, [<Xn|SP>{, #0}]

## CASALH (L == 1 && o0 == 1)

CASALH <Ws>, <Wt>, [<Xn|SP>{, #0}]

## CASH (L == 0 && o0 == 0)

CASH <Ws>, <Wt>, [<Xn|SP>{, #0}]

## CASLH (L == 0 && o0 == 1)

CASLH <Ws>, <Wt>, [<Xn|SP>{, #0}]

```
if !HaveAtomicExt() then UNDEFINED;

integer n = UInt(Rn);
integer t = UInt(Rt);
integer s = UInt(Rs);

AccType ldacctype = if L == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if o0 == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register to be compared and loaded, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be conditionally stored, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(16) comparevalue;
bits(16) newvalue;
bits(16) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

comparevalue = X[s];
newvalue = X[t];

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomicCompareAndSwap(address, comparevalue, newvalue, ldacctype, stacctype);
X[s] = ZeroExtend(data, 32);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

CASP, CASPA, CASPAL, CASPL

Compare and Swap Pair of words or doublewords in memory reads a pair of 32-bit words or 64-bit doublewords from memory, and compares them against the values held in the first pair of registers. If the comparison is equal, the values in the second pair of registers are written to memory. If the writes are performed, the reads and writes occur atomically such that no other modification of the memory location can take place between the reads and writes.

- CASPA and CASPAL load from memory with acquire semantics.
- CASPL and CASPAL store to memory with release semantics.
- CAS has neither acquire nor release semantics.

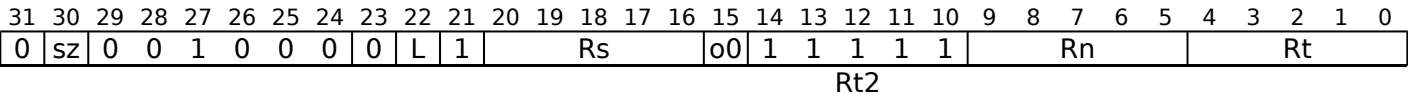
For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

The architecture permits that the data read clears any exclusive monitors associated with that location, even if the compare subsequently fails.

If the instruction generates a synchronous Data Abort, the registers which are compared and loaded, that is <Ws> and <W(s+1)>, or <Xs> and <X(s+1)>, are restored to the values held in the registers before the instruction was executed.

No offset  
(FEAT\_LSE)



### 32-bit CASP (sz == 0 && L == 0 && o0 == 0)

CASP <Ws>, <W(s+1)>, <Wt>, <W(t+1)>, [<Xn|SP>{, #0}]

### 32-bit CASPA (sz == 0 && L == 1 && o0 == 0)

CASPA <Ws>, <W(s+1)>, <Wt>, <W(t+1)>, [<Xn|SP>{, #0}]

### 32-bit CASPAL (sz == 0 && L == 1 && o0 == 1)

CASPAL <Ws>, <W(s+1)>, <Wt>, <W(t+1)>, [<Xn|SP>{, #0}]

### 32-bit CASPL (sz == 0 && L == 0 && o0 == 1)

CASPL <Ws>, <W(s+1)>, <Wt>, <W(t+1)>, [<Xn|SP>{, #0}]

### 64-bit CASP (sz == 1 && L == 0 && o0 == 0)

CASP <Xs>, <X(s+1)>, <Xt>, <X(t+1)>, [<Xn|SP>{, #0}]

### 64-bit CASPA (sz == 1 && L == 1 && o0 == 0)

CASPA <Xs>, <X(s+1)>, <Xt>, <X(t+1)>, [<Xn|SP>{, #0}]

### 64-bit CASPAL (sz == 1 && L == 1 && o0 == 1)

CASPAL <Xs>, <X(s+1)>, <Xt>, <X(t+1)>, [<Xn|SP>{, #0}]

### 64-bit CASPL (sz == 1 && L == 0 && o0 == 1)

CASPL <Xs>, <X(s+1)>, <Xt>, <X(t+1)>, [<Xn|SP>{, #0}]

```

if !HaveAtomicExt() then UNDEFINED;
if Rs<0> == '1' then UNDEFINED;
if Rt<0> == '1' then UNDEFINED;

integer n = UInt(Rn);
integer t = UInt(Rt);
integer s = UInt(Rs);

integer datasize = 32 << UInt(sz);
AccType ldacctype = if L == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if o0 == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;

```

## Assembler Symbols

<Ws>	Is the 32-bit name of the first general-purpose register to be compared and loaded, encoded in the "Rs" field. <Ws> must be an even-numbered register.
<W(s+1)>	Is the 32-bit name of the second general-purpose register to be compared and loaded.
<Wt>	Is the 32-bit name of the first general-purpose register to be conditionally stored, encoded in the "Rt" field. <Wt> must be an even-numbered register.
<W(t+1)>	Is the 32-bit name of the second general-purpose register to be conditionally stored.
<Xs>	Is the 64-bit name of the first general-purpose register to be compared and loaded, encoded in the "Rs" field. <Xs> must be an even-numbered register.
<X(s+1)>	Is the 64-bit name of the second general-purpose register to be compared and loaded.
<Xt>	Is the 64-bit name of the first general-purpose register to be conditionally stored, encoded in the "Rt" field. <Xt> must be an even-numbered register.

- <X(t+1)> Is the 64-bit name of the second general-purpose register to be conditionally stored.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```

bits(64) address;
bits(2*datasize) comparevalue;
bits(2*datasize) newvalue;
bits(2*datasize) data;

bits(datasize) s1 = X[s];
bits(datasize) s2 = X[s+1];
bits(datasize) t1 = X[t];
bits(datasize) t2 = X[t+1];
comparevalue = if BigEndian(ldacctype) then s1:s2 else s2:s1;
newvalue = if BigEndian(stacctype) then t1:t2 else t2:t1;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomicCompareAndSwap(address, comparevalue, newvalue, ldacctype, stacctype);

if BigEndian(ldacctype) then
    X[s] = data<2*datasize-1:datasize>;
    X[s+1] = data<datasize-1:0>;
else
    X[s] = data<datasize-1:0>;
    X[s+1] = data<2*datasize-1:datasize>;

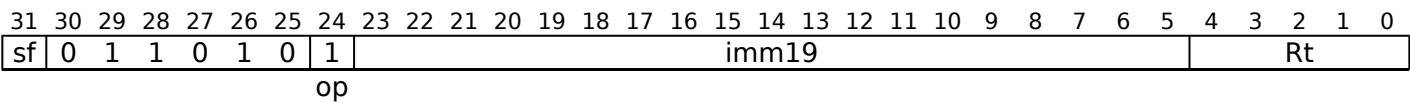
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# CBNZ

Compare and Branch on Nonzero compares the value in a register with zero, and conditionally branches to a label at a PC-relative offset if the comparison is not equal. It provides a hint that this is not a subroutine call or return. This instruction does not affect the condition flags.



## 32-bit (sf == 0)

CBNZ <Wt>, <label>

## 64-bit (sf == 1)

CBNZ <Xt>, <label>

```
integer t = UInt(Rt);
integer datasize = if sf == '1' then 64 else 32;
bits(64) offset = SignExtend(imm19:'00', 64);
```

## Assembler Symbols

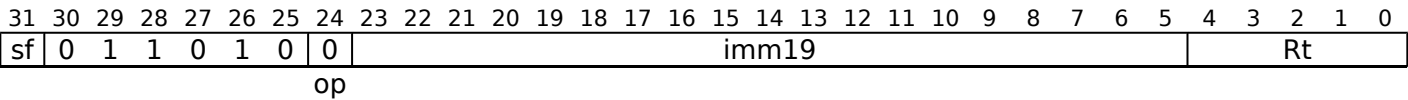
- <Wt> Is the 32-bit name of the general-purpose register to be tested, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be tested, encoded in the "Rt" field.
- <label> Is the program label to be conditionally branched to. Its offset from the address of this instruction, in the range +/-1MB, is encoded as "imm19" times 4.

## Operation

```
bits(datasize) operand1 = X[t];
if IsZero(operand1) == FALSE then
    BranchTo(PC[] + offset, BranchType_DIR, TRUE);
```

# CBZ

Compare and Branch on Zero compares the value in a register with zero, and conditionally branches to a label at a PC-relative offset if the comparison is equal. It provides a hint that this is not a subroutine call or return. This instruction does not affect condition flags.



## 32-bit (sf == 0)

```
CBZ <Wt>, <label>
```

## 64-bit (sf == 1)

```
CBZ <Xt>, <label>
```

```
integer t = UInt(Rt);
integer datasize = if sf == '1' then 64 else 32;
bits(64) offset = SignExtend(imm19:'00', 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be tested, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be tested, encoded in the "Rt" field.
- <label> Is the program label to be conditionally branched to. Its offset from the address of this instruction, in the range +/-1MB, is encoded as "imm19" times 4.

## Operation

```
bits(datasize) operand1 = X[t];
if IsZero(operand1) == TRUE then
    BranchTo(PC[] + offset, BranchType_DIR, TRUE);
```

## CCMN (immediate)

Conditional Compare Negative (immediate) sets the value of the condition flags to the result of the comparison of a register value and a negated immediate value if the condition is TRUE, and an immediate value otherwise.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
sf	0	1	1	1	0	1	0	0	1	0	imm5					cond					1	0	Rn					0	nzcv			
op																																

### 32-bit (sf == 0)

CCMN <Wn>, #<imm>, #<nzcv>, <cond>

### 64-bit (sf == 1)

CCMN <Xn>, #<imm>, #<nzcv>, <cond>

```
integer n = UInt(Rn);
integer datasize = if sf == '1' then 64 else 32;
bits(4) flags = nzcv;
bits(datasize) imm = ZeroExtend(imm5, datasize);
```

## Assembler Symbols

- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <imm> Is a five bit unsigned (positive) immediate encoded in the "imm5" field.
- <nzcv> Is the flag bit specifier, an immediate in the range 0 to 15, giving the alternative state for the 4-bit NZCV condition flags, encoded in the "nzcv" field.
- <cond> Is one of the standard conditions, encoded in the "cond" field in the standard way.

## Operation

```
if ConditionHolds(cond) then
    bits(datasize) operand1 = X[n];
    (-, flags) = AddWithCarry(operand1, imm, '0');
PSTATE.<N,Z,C,V> = flags;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



## CCMN (register)

Conditional Compare Negative (register) sets the value of the condition flags to the result of the comparison of a register value and the inverse of another register value if the condition is TRUE, and an immediate value otherwise.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	1	1	1	0	1	0	0	1	0	Rm				cond				0	0	Rn				0	nzcw					
op																															

### 32-bit (sf == 0)

CCMN <Wn>, <Wm>, #<nzcw>, <cond>

### 64-bit (sf == 1)

CCMN <Xn>, <Xm>, #<nzcw>, <cond>

```
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
bits(4) flags = nzcw;
```

## Assembler Symbols

- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <nzcw> Is the flag bit specifier, an immediate in the range 0 to 15, giving the alternative state for the 4-bit NZCV condition flags, encoded in the "nzcw" field.
- <cond> Is one of the standard conditions, encoded in the "cond" field in the standard way.

## Operation

```
if ConditionHolds(cond) then
    bits(datasize) operand1 = X[n];
    bits(datasize) operand2 = X[m];
    (-, flags) = AddWithCarry(operand1, operand2, '0');
PSTATE.<N,Z,C,V> = flags;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## CCMP (immediate)

Conditional Compare (immediate) sets the value of the condition flags to the result of the comparison of a register value and an immediate value if the condition is TRUE, and an immediate value otherwise.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
sf	1	1	1	1	0	1	0	0	1	0	imm5					cond					1	0	Rn					0	nzcvc			
op																																

### 32-bit (sf == 0)

CCMP <Wn>, #<imm>, #<nzcvc>, <cond>

### 64-bit (sf == 1)

CCMP <Xn>, #<imm>, #<nzcvc>, <cond>

```
integer n = UInt(Rn);
integer datasize = if sf == '1' then 64 else 32;
bits(4) flags = nzcvc;
bits(datasize) imm = ZeroExtend(imm5, datasize);
```

## Assembler Symbols

- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <imm> Is a five bit unsigned (positive) immediate encoded in the "imm5" field.
- <nzcvc> Is the flag bit specifier, an immediate in the range 0 to 15, giving the alternative state for the 4-bit NZCV condition flags, encoded in the "nzcvc" field.
- <cond> Is one of the standard conditions, encoded in the "cond" field in the standard way.

## Operation

```
if ConditionHolds(cond) then
    bits(datasize) operand1 = X[n];
    bits(datasize) operand2;
    operand2 = NOT(imm);
    (-, flags) = AddWithCarry(operand1, operand2, '1');
PSTATE.<N,Z,C,V> = flags;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# CCMP (register)

Conditional Compare (register) sets the value of the condition flags to the result of the comparison of two registers if the condition is TRUE, and an immediate value otherwise.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	1	1	1	1	0	1	0	0	1	0	Rm				cond				0	0	Rn				0	nzcw					
op																															

## 32-bit (sf == 0)

CCMP <Wn>, <Wm>, #<nzcw>, <cond>

## 64-bit (sf == 1)

CCMP <Xn>, <Xm>, #<nzcw>, <cond>

```
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
bits(4) flags = nzcw;
```

## Assembler Symbols

- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <nzcw> Is the flag bit specifier, an immediate in the range 0 to 15, giving the alternative state for the 4-bit NZCW condition flags, encoded in the "nzcw" field.
- <cond> Is one of the standard conditions, encoded in the "cond" field in the standard way.

## Operation

```
if ConditionHolds(cond) then
    bits(datasize) operand1 = X[n];
    bits(datasize) operand2 = X[m];
    operand2 = NOT(operand2);
    (-, flags) = AddWithCarry(operand1, operand2, '1');
PSTATE.<N,Z,C,V> = flags;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCW flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCW flags.

# CFINV

Invert Carry Flag. This instruction inverts the value of the PSTATE.C flag.

## System

(FEAT\_FlagM)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	(0)	(0)	(0)	(0)	0	0	0	1	1	1	1	1
CRm																															

## CFINV

```
if !HaveFlagManipulateExt() then UNDEFINED;
```

## Operation

```
PSTATE.C = NOT(PSTATE.C);
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41  
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

CFP

Control Flow Prediction Restriction by Context prevents control flow predictions that predict execution addresses based on information gathered from earlier execution within a particular execution context. Control flow predictions determined by the actions of code in the target execution context or contexts appearing in program order before the instruction cannot be used to exploitatively control speculative execution occurring after the instruction is complete and synchronized.

For more information, see *CFP RCTX, Control Flow Prediction Restriction by Context*.

This is an alias of [SYS](#). This means:

- The encodings in this description are named to match the encodings of [SYS](#).
- The description of [SYS](#) gives the operational pseudocode for this instruction.

System

(FEAT\_SPECRES)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	1	0	1	1	0	1	1	1	0	0	1	1	1	0	0					Rt
										L			op1			CRn			CRm			op2									

CFP RCTX, [<Xt>](#)

is equivalent to

[SYS](#) #3, C7, C3, #4, [<Xt>](#)

and is always the preferred disassembly.

Assembler Symbols

[<Xt>](#) Is the 64-bit name of the general-purpose source register, encoded in the "Rt" field.

Operation

The description of [SYS](#) gives the operational pseudocode for this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# CINC

Conditional Increment returns, in the destination register, the value of the source register incremented by 1 if the condition is TRUE, and otherwise returns the value of the source register.

This is an alias of CSINC. This means:

- The encodings in this description are named to match the encodings of CSINC.
- The description of CSINC gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	0	1	1	0	1	0	1	0	0	!= 11111				!= 111x				0	1	!= 11111				Rd						
op			Rm								cond				o2		Rn														

## 32-bit (sf == 0)

CINC <Wd>, <Wn>, <cond>

is equivalent to

CSINC <Wd>, <Wn>, <Wn>, invert(<cond>)

and is the preferred disassembly when Rn == Rm.

## 64-bit (sf == 1)

CINC <Xd>, <Xn>, <cond>

is equivalent to

CSINC <Xd>, <Xn>, <Xn>, invert(<cond>)

and is the preferred disassembly when Rn == Rm.

## Assembler Symbols

- |        |  |
|--------|--|
| <Wd>   | Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.                                   |
| <Wn>   | Is the 32-bit name of the general-purpose source register, encoded in the "Rn" and "Rm" fields.                              |
| <Xd>   | Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.                                   |
| <Xn>   | Is the 64-bit name of the general-purpose source register, encoded in the "Rn" and "Rm" fields.                              |
| <cond> | Is one of the standard conditions, excluding AL and NV, encoded in the "cond" field with its least significant bit inverted. |

## Operation

The description of CSINC gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

# CINV

Conditional Invert returns, in the destination register, the bitwise inversion of the value of the source register if the condition is TRUE, and otherwise returns the value of the source register.

This is an alias of [CSINV](#). This means:

- The encodings in this description are named to match the encodings of [CSINV](#).
- The description of [CSINV](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
sf	1	0	1	1	0	1	0	1	0	0	!= 11111				!= 111x				0	0	!= 11111				Rd							
op											Rm								cond				o2		Rn							

## 32-bit (sf == 0)

CINV <Wd>, <Wn>, <cond>

is equivalent to

[CSINV](#) <Wd>, <Wn>, <Wn>, invert(<cond>)

and is the preferred disassembly when Rn == Rm.

## 64-bit (sf == 1)

CINV <Xd>, <Xn>, <cond>

is equivalent to

[CSINV](#) <Xd>, <Xn>, <Xn>, invert(<cond>)

and is the preferred disassembly when Rn == Rm.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" and "Rm" fields.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" and "Rm" fields.
<cond>	Is one of the standard conditions, excluding AL and NV, encoded in the "cond" field with its least significant bit inverted.

## Operation

The description of [CSINV](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

# CLREX

Clear Exclusive clears the local monitor of the executing PE.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	1	CRm			0	1	0	1	1	1	1	1	1

CLREX {#<imm>}

// CRm field is ignored

## Assembler Symbols

<imm> Is an optional 4-bit unsigned immediate, in the range 0 to 15, defaulting to 15 and encoded in the "CRm" field.

## Operation

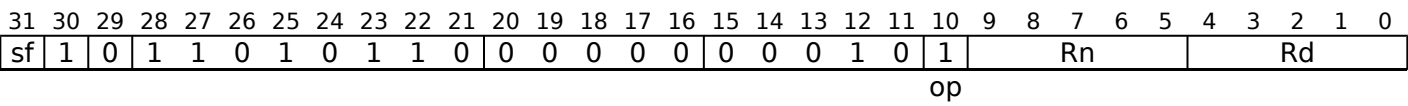
[ClearExclusiveLocal](#)([ProcessorID](#)() );

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41  
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# CLS

Count Leading Sign bits counts the number of leading bits of the source register that have the same value as the most significant bit of the register, and writes the result to the destination register. This count does not include the most significant bit of the source register.



## 32-bit (sf == 0)

CLS <Wd>, <Wn>

## 64-bit (sf == 1)

CLS <Xd>, <Xn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer datasize = if sf == '1' then 64 else 32;
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.

## Operation

```
integer result;
bits(datasize) operand1 = X[n];

result = CountLeadingSignBits(operand1);

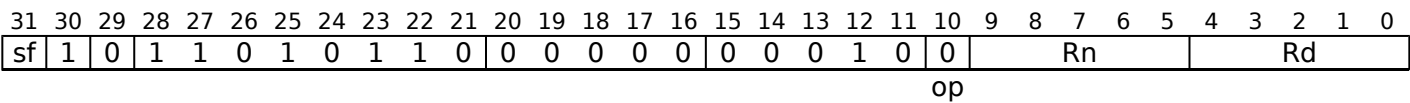
X[d] = result<datasize-1:0>;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# CLZ

Count Leading Zeros counts the number of binary zero bits before the first binary one bit in the value of the source register, and writes the result to the destination register.



## 32-bit (sf == 0)

CLZ <Wd>, <Wn>

## 64-bit (sf == 1)

CLZ <Xd>, <Xn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer datasize = if sf == '1' then 64 else 32;
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.

## Operation

```
integer result;
bits(datasize) operand1 = X[n];

result = CountLeadingZeroBits(operand1);
X[d] = result<datasize-1:0>;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

## CMN (extended register)

Compare Negative (extended register) adds a register value and a sign or zero-extended register value, followed by an optional left shift amount. The argument that is extended from the <Rm> register can be a byte, halfword, word, or doubleword. It updates the condition flags based on the result, and discards the result.

This is an alias of [ADDS \(extended register\)](#). This means:

- The encodings in this description are named to match the encodings of [ADDS \(extended register\)](#).
- The description of [ADDS \(extended register\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
sf	0	1	0	1	0	1	1	0	0	1	Rm					option			imm3			Rn					1	1	1	1	1	
op S																												Rd				

### 32-bit (sf == 0)

CMN <Wn|WSP>, <Wm>{, <extend> {#<amount>}}

is equivalent to

ADDS WZR, <Wn|WSP>, <Wm>{, <extend> {#<amount>}}

and is always the preferred disassembly.

### 64-bit (sf == 1)

CMN <Xn|SP>, <R><m>{, <extend> {#<amount>}}

is equivalent to

ADDS XZR, <Xn|SP>, <R><m>{, <extend> {#<amount>}}

and is always the preferred disassembly.

## Assembler Symbols

<Wn|WSP> Is the 32-bit name of the first source general-purpose register or stack pointer, encoded in the "Rn" field.

<Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.

<Xn|SP> Is the 64-bit name of the first source general-purpose register or stack pointer, encoded in the "Rn" field.

<R> Is a width specifier, encoded in "option":

option	<R>
00x	W
010	W
x11	X
10x	W
110	W

<m> Is the number [0-30] of the second general-purpose source register or the name ZR (31), encoded in the "Rm" field.

<extend> For the 32-bit variant: is the extension to be applied to the second source operand, encoded in "option":

option	<extend>
000	UXTB
001	UXTH
010	LSL UXTW
011	UXTX
100	SXTB
101	SXTH
110	SXTW
111	SXTX

If "Rn" is '11111' (WSP) and "option" is '010' then LSL is preferred, but may be omitted when "imm3" is '000'. In all other cases <extend> is required and must be UXTW when "option" is '010'.

For the 64-bit variant: is the extension to be applied to the second source operand, encoded in "option":

option	<extend>
000	UXTB
001	UXTH
010	UXTW
011	LSL UXTX
100	SXTB
101	SXTH
110	SXTW
111	SXTX

If "Rn" is '11111' (SP) and "option" is '011' then LSL is preferred, but may be omitted when "imm3" is '000'. In all other cases <extend> is required and must be UXTX when "option" is '011'.

<amount> Is the left shift amount to be applied after extension in the range 0 to 4, defaulting to 0, encoded in the "imm3" field. It must be absent when <extend> is absent, is required when <extend> is LSL, and is optional when <extend> is present but not LSL.

## Operation

The description of [ADDS \(extended register\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

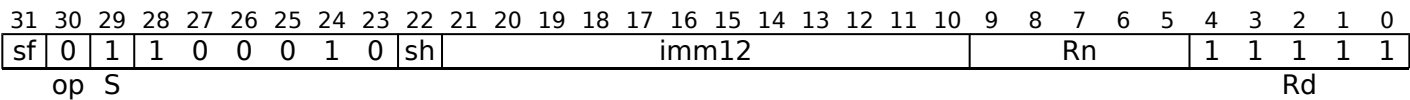
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# CMN (immediate)

Compare Negative (immediate) adds a register value and an optionally-shifted immediate value. It updates the condition flags based on the result, and discards the result.

This is an alias of [ADDS \(immediate\)](#). This means:

- The encodings in this description are named to match the encodings of [ADDS \(immediate\)](#).
- The description of [ADDS \(immediate\)](#) gives the operational pseudocode for this instruction.



## 32-bit (sf == 0)

CMN <Wn|WSP>, #<imm>{, <shift>}

is equivalent to

ADDS WZR, <Wn|WSP>, #<imm> {, <shift>}

and is always the preferred disassembly.

## 64-bit (sf == 1)

CMN <Xn|SP>, #<imm>{, <shift>}

is equivalent to

ADDS XZR, <Xn|SP>, #<imm> {, <shift>}

and is always the preferred disassembly.

## Assembler Symbols

- <Wn|WSP> Is the 32-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.
- <Xn|SP> Is the 64-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.
- <imm> Is an unsigned immediate, in the range 0 to 4095, encoded in the "imm12" field.
- <shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #12

## Operation

The description of [ADDS \(immediate\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.



# CMN (shifted register)

Compare Negative (shifted register) adds a register value and an optionally-shifted register value. It updates the condition flags based on the result, and discards the result.

This is an alias of [ADDS \(shifted register\)](#). This means:

- The encodings in this description are named to match the encodings of [ADDS \(shifted register\)](#).
- The description of [ADDS \(shifted register\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
sf	0	1	0	1	0	1	1	shift	0	Rm						imm6						Rn						1	1	1	1	1
op S																				Rd												

## 32-bit (sf == 0)

CMN <Wn>, <Wm>{, <shift> #<amount>}

is equivalent to

ADDS WZR, <Wn>, <Wm> {, <shift> #<amount>}

and is always the preferred disassembly.

## 64-bit (sf == 1)

CMN <Xn>, <Xm>{, <shift> #<amount>}

is equivalent to

ADDS XZR, <Xn>, <Xm> {, <shift> #<amount>}

and is always the preferred disassembly.

## Assembler Symbols

- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <shift> Is the optional shift type to be applied to the second source operand, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	RESERVED

- <amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.
- For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field.

## Operation

The description of [ADDS \(shifted register\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# CMP (extended register)

Compare (extended register) subtracts a sign or zero-extended register value, followed by an optional left shift amount, from a register value. The argument that is extended from the <Rm> register can be a byte, halfword, word, or doubleword. It updates the condition flags based on the result, and discards the result.

This is an alias of [SUBS \(extended register\)](#). This means:

- The encodings in this description are named to match the encodings of [SUBS \(extended register\)](#).
  - The description of [SUBS \(extended register\)](#) gives the operational pseudocode for this instruction.
- |      |    |    |    |    |    |    |    |    |    |    |    |    |    |    |        |    |      |    |    |    |    |   |           |   |   |   |    |   |   |   |   |
|------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|--------|----|------|----|----|----|----|---|-----------|---|---|---|----|---|---|---|---|
| 31   | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16     | 15 | 14   | 13 | 12 | 11 | 10 | 9 | 8         | 7 | 6 | 5 | 4  | 3 | 2 | 1 | 0 |
| sf   | 1  | 1  | 0  | 1  | 0  | 1  | 1  | 0  | 0  | 1  | Rm |    |    |    | option |    | imm3 |    | Rn |    |    |   | 1 1 1 1 1 |   |   |   |    |   |   |   |   |
| op S |    |    |    |    |    |    |    |    |    |    |    |    |    |    |        |    |      |    |    |    |    |   |           |   |   |   | Rd |   |   |   |   |

## 32-bit (sf == 0)

CMP <Wn|WSP>, <Wm>{, <extend> {#<amount>}}

is equivalent to

SUBS WZR, <Wn|WSP>, <Wm>{, <extend> {#<amount>}}

and is always the preferred disassembly.

## 64-bit (sf == 1)

CMP <Xn|SP>, <R><m>{, <extend> {#<amount>}}

is equivalent to

SUBS XZR, <Xn|SP>, <R><m>{, <extend> {#<amount>}}

and is always the preferred disassembly.

## Assembler Symbols

- <Wn|WSP> Is the 32-bit name of the first source general-purpose register or stack pointer, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xn|SP> Is the 64-bit name of the first source general-purpose register or stack pointer, encoded in the "Rn" field.
- <R> Is a width specifier, encoded in "option":
- | option | <R> |
|--------|-----|
| 00x    | W   |
| 010    | W   |
| x11    | X   |
| 10x    | W   |
| 110    | W   |
- <m> Is the number [0-30] of the second general-purpose source register or the name ZR (31), encoded in the "Rm" field.
- <extend> For the 32-bit variant: is the extension to be applied to the second source operand, encoded in "option":

option	<extend>
000	UXTB
001	UXTH
010	LSL UXTW
011	UXTX
100	SXTB
101	SXTH
110	SXTW
111	SXTX

If "Rn" is '11111' (WSP) and "option" is '010' then LSL is preferred, but may be omitted when "imm3" is '000'. In all other cases <extend> is required and must be UXTW when "option" is '010'.

For the 64-bit variant: is the extension to be applied to the second source operand, encoded in "option":

option	<extend>
000	UXTB
001	UXTH
010	UXTW
011	LSL UXTX
100	SXTB
101	SXTH
110	SXTW
111	SXTX

If "Rn" is '11111' (SP) and "option" is '011' then LSL is preferred, but may be omitted when "imm3" is '000'. In all other cases <extend> is required and must be UXTX when "option" is '011'.

<amount> Is the left shift amount to be applied after extension in the range 0 to 4, defaulting to 0, encoded in the "imm3" field. It must be absent when <extend> is absent, is required when <extend> is LSL, and is optional when <extend> is present but not LSL.

## Operation

The description of [SUBS \(extended register\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# CMP (immediate)

Compare (immediate) subtracts an optionally-shifted immediate value from a register value. It updates the condition flags based on the result, and discards the result.

This is an alias of [SUBS \(immediate\)](#). This means:

- The encodings in this description are named to match the encodings of [SUBS \(immediate\)](#).
  - The description of [SUBS \(immediate\)](#) gives the operational pseudocode for this instruction.
- |      |    |    |    |    |    |    |    |    |    |       |    |    |    |    |    |    |    |    |    |    |    |    |   |   |           |   |   |    |   |   |   |  |
|------|----|----|----|----|----|----|----|----|----|-------|----|----|----|----|----|----|----|----|----|----|----|----|---|---|-----------|---|---|----|---|---|---|--|
| 31   | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21    | 20 | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9  | 8 | 7 | 6         | 5 | 4 | 3  | 2 | 1 | 0 |  |
| sf   | 1  | 1  | 1  | 0  | 0  | 0  | 1  | 0  | sh | imm12 |    |    |    |    |    |    |    |    |    |    |    | Rn |   |   | 1 1 1 1 1 |   |   |    |   |   |   |  |
| op S |    |    |    |    |    |    |    |    |    |       |    |    |    |    |    |    |    |    |    |    |    |    |   |   |           |   |   | Rd |   |   |   |  |

## 32-bit (sf == 0)

CMP <Wn|WSP>, #<imm>{, <shift>}

is equivalent to

SUBS WZR, <Wn|WSP>, #<imm> {, <shift>}

and is always the preferred disassembly.

## 64-bit (sf == 1)

CMP <Xn|SP>, #<imm>{, <shift>}

is equivalent to

SUBS XZR, <Xn|SP>, #<imm> {, <shift>}

and is always the preferred disassembly.

## Assembler Symbols

- <Wn|WSP> Is the 32-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.
- <Xn|SP> Is the 64-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.
- <imm> Is an unsigned immediate, in the range 0 to 4095, encoded in the "imm12" field.
- <shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #12

## Operation

The description of [SUBS \(immediate\)](#) gives the operational pseudocode for this instruction.

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.



# CMP (shifted register)

Compare (shifted register) subtracts an optionally-shifted register value from a register value. It updates the condition flags based on the result, and discards the result.

This is an alias of [SUBS \(shifted register\)](#). This means:

- The encodings in this description are named to match the encodings of [SUBS \(shifted register\)](#).
  - The description of [SUBS \(shifted register\)](#) gives the operational pseudocode for this instruction.
- |      |    |    |    |    |    |    |    |       |    |    |    |    |    |    |    |      |    |    |    |    |    |    |   |   |   |   |    |   |   |   |   |
|------|----|----|----|----|----|----|----|-------|----|----|----|----|----|----|----|------|----|----|----|----|----|----|---|---|---|---|----|---|---|---|---|
| 31   | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23    | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15   | 14 | 13 | 12 | 11 | 10 | 9  | 8 | 7 | 6 | 5 | 4  | 3 | 2 | 1 | 0 |
| sf   | 1  | 1  | 0  | 1  | 0  | 1  | 1  | shift | 0  | Rm |    |    |    |    |    | imm6 |    |    |    |    |    | Rn |   |   | 1 | 1 | 1  | 1 | 1 |   |   |
| op S |    |    |    |    |    |    |    |       |    |    |    |    |    |    |    |      |    |    |    |    |    |    |   |   |   |   | Rd |   |   |   |   |

## 32-bit (sf == 0)

CMP <Wn>, <Wm>{, <shift> #<amount>}

is equivalent to

[SUBS](#) WZR, <Wn>, <Wm> {, <shift> #<amount>}

and is always the preferred disassembly.

## 64-bit (sf == 1)

CMP <Xn>, <Xm>{, <shift> #<amount>}

is equivalent to

[SUBS](#) XZR, <Xn>, <Xm> {, <shift> #<amount>}

and is always the preferred disassembly.

## Assembler Symbols

- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <shift> Is the optional shift type to be applied to the second source operand, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	RESERVED

- <amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.
- For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field.

## Operation

The description of [SUBS \(shifted register\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# CMPP

Compare with Tag subtracts the 56-bit address held in the second source register from the 56-bit address held in the first source register, updates the condition flags based on the result of the subtraction, and discards the result.

This is an alias of [SUBPS](#). This means:

- The encodings in this description are named to match the encodings of [SUBPS](#).
- The description of [SUBPS](#) gives the operational pseudocode for this instruction.

## Integer (Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	1	1	0	1	0	1	1	0	Xm					0	0	0	0	0	0	Xn					1	1	1	1	1
																												Xd			

CMPP <Xn|SP>, <Xm|SP>

is equivalent to

[SUBPS](#) XZR, <Xn|SP>, <Xm|SP>

and is always the preferred disassembly.

## Assembler Symbols

<Xn|SP>

Is the 64-bit name of the first source general-purpose register or stack pointer, encoded in the "Xn" field.

<Xm|SP>

Is the 64-bit name of the second general-purpose source register or stack pointer, encoded in the "Xm" field.

## Operation

The description of [SUBPS](#) gives the operational pseudocode for this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# CNEG

Conditional Negate returns, in the destination register, the negated value of the source register if the condition is TRUE, and otherwise returns the value of the source register.

This is an alias of [CSNEG](#). This means:

- The encodings in this description are named to match the encodings of [CSNEG](#).
- The description of [CSNEG](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf		1	0	1	1	0	1	0	1	0	0	Rm				!= 111x				0	1	Rn				Rd					
op												cond				o2															

## 32-bit (sf == 0)

CNEG <Wd>, <Wn>, <cond>

is equivalent to

[CSNEG](#) <Wd>, <Wn>, <Wn>, invert(<cond>)

and is the preferred disassembly when **Rn == Rm**.

## 64-bit (sf == 1)

CNEG <Xd>, <Xn>, <cond>

is equivalent to

[CSNEG](#) <Xd>, <Xn>, <Xn>, invert(<cond>)

and is the preferred disassembly when **Rn == Rm**.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" and "Rm" fields.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" and "Rm" fields.
<cond>	Is one of the standard conditions, excluding AL and NV, encoded in the "cond" field with its least significant bit inverted.

## Operation

The description of [CSNEG](#) gives the operational pseudocode for this instruction.

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



CPP

Cache Prefetch Prediction Restriction by Context prevents cache allocation predictions that predict execution addresses based on information gathered from earlier execution within a particular execution context. Cache allocation predictions determined by the actions of code in the target execution context or contexts appearing in program order before the instruction cannot be used to exploitatively control speculative execution occurring after the instruction is complete and synchronized.

For more information, see *CPP RCTX, Cache Prefetch Prediction Restriction by Context*.

This is an alias of [SYS](#). This means:

- The encodings in this description are named to match the encodings of [SYS](#).
- The description of [SYS](#) gives the operational pseudocode for this instruction.

System  
(FEAT\_SPECRES)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	1	0	1	1	0	1	1	1	0	0	1	1	1	1	1	1	Rt			
L										op1			CRn			CRm			op2												

CPP RCTX, [<Xt>](#)

is equivalent to

[SYS](#) #3, C7, C3, #7, [<Xt>](#)

and is always the preferred disassembly.

Assembler Symbols

[<Xt>](#) Is the 64-bit name of the general-purpose source register, encoded in the "Rt" field.

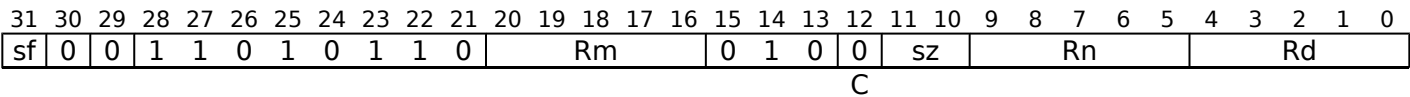
Operation

The description of [SYS](#) gives the operational pseudocode for this instruction.

# CRC32B, CRC32H, CRC32W, CRC32X

CRC32 checksum performs a cyclic redundancy check (CRC) calculation on a value held in a general-purpose register. It takes an input CRC value in the first source operand, performs a CRC on the input value in the second source operand, and returns the output CRC value. The second source operand can be 8, 16, 32, or 64 bits. To align with common usage, the bit order of the values is reversed as part of the operation, and the polynomial 0x04C11DB7 is used for the CRC calculation.

In Armv8-A, this is an OPTIONAL instruction, and in Armv8.1 it is mandatory for all implementations to implement it. [ID\\_AA64ISAR0\\_EL1](#).CRC32 indicates whether this instruction is supported.



## CRC32B (sf == 0 && sz == 00)

CRC32B <Wd>, <Wn>, <Wm>

## CRC32H (sf == 0 && sz == 01)

CRC32H <Wd>, <Wn>, <Wm>

## CRC32W (sf == 0 && sz == 10)

CRC32W <Wd>, <Wn>, <Wm>

## CRC32X (sf == 1 && sz == 11)

CRC32X <Wd>, <Wn>, <Xm>

```
if !HaveCRCExt() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sf == '1' && sz != '11' then UNDEFINED;
if sf == '0' && sz == '11' then UNDEFINED;
integer size = 8 << UInt(sz);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose accumulator output register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the general-purpose accumulator input register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose data source register, encoded in the "Rm" field.
- <Wm> Is the 32-bit name of the general-purpose data source register, encoded in the "Rm" field.

## Operation

```
bits(32) acc = X[n]; // accumulator
bits(size) val = X[m]; // input value
bits(32) poly = 0x04C11DB7<31:0>;

bits(32+size) tempacc = BitReverse(acc):Zeros(size);
bits(size+32) tempval = BitReverse(val):Zeros(32);

// Poly32Mod2 on a bitstring does a polynomial Modulus over {0,1} operation
X[d] = BitReverse(Poly32Mod2(tempacc EOR tempval, poly));
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

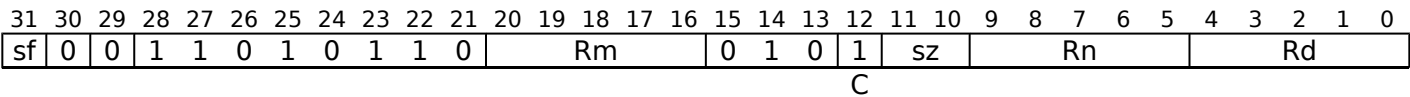
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# CRC32CB, CRC32CH, CRC32CW, CRC32CX

CRC32 checksum performs a cyclic redundancy check (CRC) calculation on a value held in a general-purpose register. It takes an input CRC value in the first source operand, performs a CRC on the input value in the second source operand, and returns the output CRC value. The second source operand can be 8, 16, 32, or 64 bits. To align with common usage, the bit order of the values is reversed as part of the operation, and the polynomial 0x1EDC6F41 is used for the CRC calculation.

In Armv8-A, this is an OPTIONAL instruction, and in Armv8.1 it is mandatory for all implementations to implement it. [ID\\_AA64ISAR0\\_EL1.CRC32](#) indicates whether this instruction is supported.



## CRC32CB (sf == 0 && sz == 00)

CRC32CB <Wd>, <Wn>, <Wm>

## CRC32CH (sf == 0 && sz == 01)

CRC32CH <Wd>, <Wn>, <Wm>

## CRC32CW (sf == 0 && sz == 10)

CRC32CW <Wd>, <Wn>, <Wm>

## CRC32CX (sf == 1 && sz == 11)

CRC32CX <Wd>, <Wn>, <Xm>

```
if !HaveCRCExt() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sf == '1' && sz != '11' then UNDEFINED;
if sf == '0' && sz == '11' then UNDEFINED;
integer size = 8 << UInt(sz);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose accumulator output register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the general-purpose accumulator input register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose data source register, encoded in the "Rm" field.
- <Wm> Is the 32-bit name of the general-purpose data source register, encoded in the "Rm" field.

## Operation

```
bits(32) acc = X[n]; // accumulator
bits(size) val = X[m]; // input value
bits(32) poly = 0x1EDC6F41<31:0>;

bits(32+size) tempacc = BitReverse(acc):Zeros(size);
bits(size+32) tempval = BitReverse(val):Zeros(32);

// Poly32Mod2 on a bitstring does a polynomial Modulus over {0,1} operation
X[d] = BitReverse(Poly32Mod2(tempacc EOR tempval, poly));
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

CSDB

Consumption of Speculative Data Barrier is a memory barrier that controls speculative execution and data value prediction.

No instruction other than branch instructions appearing in program order after the CSDB can be speculatively executed using the results of any:

- Data value predictions of any instructions.
- PSTATE.{N,Z,C,V} predictions of any instructions other than conditional branch instructions appearing in program order before the CSDB that have not been architecturally resolved.
- Predictions of SVE predication state for any SVE instructions.

For purposes of the definition of CSDB, PSTATE.{N,Z,C,V} is not considered a data value. This definition permits:

- Control flow speculation before and after the CSDB.
- Speculative execution of conditional data processing instructions after the CSDB, unless they use the results of data value or PSTATE.{N,Z,C,V} predictions of instructions appearing in program order before the CSDB that have not been architecturally resolved.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	1	0	1	0	0	1	1	1	1	1
																CRm				op2											

CSDB

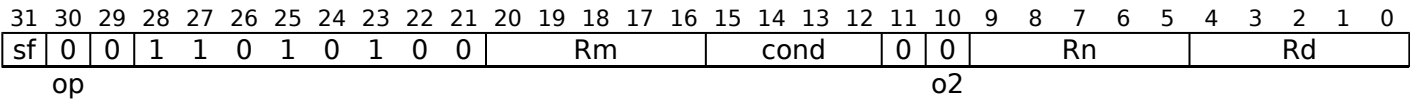
// Empty.

Operation

[ConsumptionOfSpeculativeDataBarrier\(\)](#);

# CSEL

If the condition is true, Conditional Select writes the value of the first source register to the destination register. If the condition is false, it writes the value of the second source register to the destination register.



## 32-bit (sf == 0)

CSEL <Wd>, <Wn>, <Wm>, <cond>

## 64-bit (sf == 1)

CSEL <Xd>, <Xn>, <Xm>, <cond>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <cond> Is one of the standard conditions, encoded in the "cond" field in the standard way.

## Operation

```
bits(datasize) result;
if ConditionHolds(cond) then
    result = X[n];
else
    result = X[m];
X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# CSET

Conditional Set sets the destination register to 1 if the condition is TRUE, and otherwise sets it to 0.

This is an alias of [CSINC](#). This means:

- The encodings in this description are named to match the encodings of [CSINC](#).
- The description of [CSINC](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	0	1	1	0	1	0	1	0	0	1	1	1	1	1	!= 111x	0	1	1	1	1	1	1	1	1	1					Rd
op											Rm					cond			o2		Rn										

## 32-bit (sf == 0)

CSET <Wd>, <cond>

is equivalent to

[CSINC](#) <Wd>, WZR, WZR, invert(<cond>)

and is always the preferred disassembly.

## 64-bit (sf == 1)

CSET <Xd>, <cond>

is equivalent to

[CSINC](#) <Xd>, XZR, XZR, invert(<cond>)

and is always the preferred disassembly.

## Assembler Symbols

- |        |  |
|--------|--|
| <Wd>   | Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.                                   |
| <Xd>   | Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.                                   |
| <cond> | Is one of the standard conditions, excluding AL and NV, encoded in the "cond" field with its least significant bit inverted. |

## Operation

The description of [CSINC](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# CSETM

Conditional Set Mask sets all bits of the destination register to 1 if the condition is TRUE, and otherwise sets all bits to 0.

This is an alias of [CSINV](#). This means:

- The encodings in this description are named to match the encodings of [CSINV](#).
- The description of [CSINV](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	1	0	1	1	0	1	0	1	0	0	1	1	1	1	1	!= 111x	0	0	1	1	1	1	1	Rd							
op			Rm										cond		o2		Rn														

## 32-bit (sf == 0)

CSETM <Wd>, <cond>

is equivalent to

[CSINV](#) <Wd>, WZR, WZR, invert(<cond>)

and is always the preferred disassembly.

## 64-bit (sf == 1)

CSETM <Xd>, <cond>

is equivalent to

[CSINV](#) <Xd>, XZR, XZR, invert(<cond>)

and is always the preferred disassembly.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<cond>	Is one of the standard conditions, excluding AL and NV, encoded in the "cond" field with its least significant bit inverted.

## Operation

The description of [CSINV](#) gives the operational pseudocode for this instruction.

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

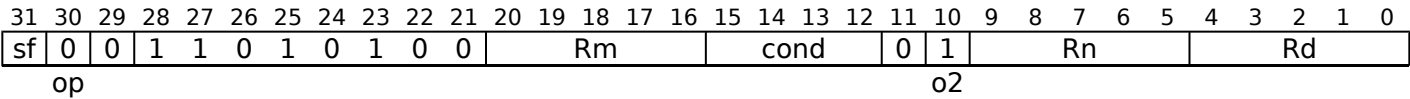
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# CSINC

Conditional Select Increment returns, in the destination register, the value of the first source register if the condition is TRUE, and otherwise returns the value of the second source register incremented by 1.

This instruction is used by the aliases [CINC](#), and [CSET](#).



## 32-bit (sf == 0)

CSINC <Wd>, <Wn>, <Wm>, <cond>

## 64-bit (sf == 1)

CSINC <Xd>, <Xn>, <Xm>, <cond>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
```

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Wm>	Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
<cond>	Is one of the standard conditions, encoded in the "cond" field in the standard way.

## Alias Conditions

Alias	Is preferred when
<a href="#">CINC</a>	Rm != '11111' && cond != '111x' && Rn != '11111' && Rn == Rm
<a href="#">CSET</a>	Rm == '11111' && cond != '111x' && Rn == '11111'

## Operation

```
bits(datasize) result;
if ConditionHolds(cond) then
    result = X[n];
else
    result = X[m];
    result = result + 1;

X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

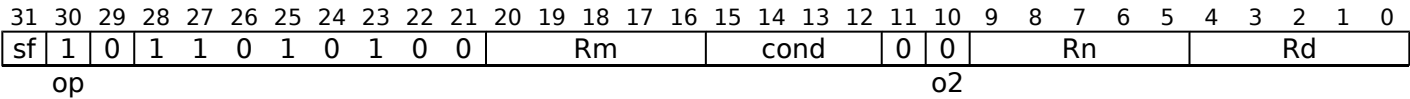
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# CSINV

Conditional Select Invert returns, in the destination register, the value of the first source register if the condition is TRUE, and otherwise returns the bitwise inversion value of the second source register.

This instruction is used by the aliases [CINV](#), and [CSETM](#).



## 32-bit (sf == 0)

CSINV <Wd>, <Wn>, <Wm>, <cond>

## 64-bit (sf == 1)

CSINV <Xd>, <Xn>, <Xm>, <cond>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
```

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Wm>	Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
<cond>	Is one of the standard conditions, encoded in the "cond" field in the standard way.

## Alias Conditions

Alias	Is preferred when
<a href="#">CINV</a>	Rm != '11111' && cond != '111x' && Rn != '11111' && Rn == Rm
<a href="#">CSETM</a>	Rm == '11111' && cond != '111x' && Rn == '11111'

## Operation

```
bits(datasize) result;
if ConditionHolds(cond) then
    result = X[n];
else
    result = X[m];
    result = NOT(result);
X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

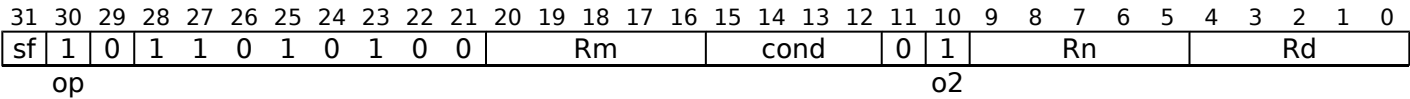
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# CSNEG

Conditional Select Negation returns, in the destination register, the value of the first source register if the condition is TRUE, and otherwise returns the negated value of the second source register.

This instruction is used by the alias [CNEG](#).



## 32-bit (sf == 0)

CSNEG <Wd>, <Wn>, <Wm>, <cond>

## 64-bit (sf == 1)

CSNEG <Xd>, <Xn>, <Xm>, <cond>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
```

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Wm>	Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
<cond>	Is one of the standard conditions, encoded in the "cond" field in the standard way.

## Alias Conditions

Alias	Is preferred when
<a href="#">CNEG</a>	cond != '111x' && Rn == Rm

## Operation

```
bits(datasize) result;
if ConditionHolds(cond) then
    result = X[n];
else
    result = X[m];
    result = NOT(result);
    result = result + 1;

X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:

- The values of the data supplied in any of its registers.
- The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

DC

Data Cache operation. For more information, see *op0==0b01, cache maintenance, TLB maintenance, and address translation instructions*.

This is an alias of [SYS](#). This means:

- The encodings in this description are named to match the encodings of [SYS](#).
- The description of [SYS](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	1	op1			0	1	1	1	CRm			op2			Rt					
L											CRn																				

DC [<dc\\_op>](#), [<Xt>](#)

is equivalent to

[SYS](#) [#<op1>](#), C7, [<Cm>](#), [#<op2>](#), [<Xt>](#)

and is the preferred disassembly when `SysOp(op1, '0111', CRm, op2) == Sys_DC`.

Assembler Symbols

[<dc\\_op>](#) Is a DC instruction name, as listed for the DC system instruction group, encoded in "op1:CRm:op2":

op1	CRm	op2	<dc_op>	Architectural Feature
000	0110	001	IVAC	-
000	0110	010	ISW	-
000	0110	011	IGVAC	FEAT_MTE2
000	0110	100	IGSW	FEAT_MTE2
000	0110	101	IGDVAC	FEAT_MTE2
000	0110	110	IGDSW	FEAT_MTE2
000	1010	010	CSW	-
000	1010	100	CGSW	FEAT_MTE2
000	1010	110	CGDSW	FEAT_MTE2
000	1110	010	CISW	-
000	1110	100	CIGSW	FEAT_MTE2
000	1110	110	CIGDSW	FEAT_MTE2
011	0100	001	ZVA	-
011	0100	011	GVA	FEAT_MTE
011	0100	100	GZVA	FEAT_MTE
011	1010	001	CVAC	-
011	1010	011	CGVAC	FEAT_MTE
011	1010	101	CGDVAC	FEAT_MTE
011	1011	001	CVAU	-
011	1100	001	CVAP	FEAT_DPB
011	1100	011	CGVAP	FEAT_MTE
011	1100	101	CGDVAP	FEAT_MTE
011	1101	001	CVADP	FEAT_DPB2
011	1101	011	CGVADP	FEAT_MTE
011	1101	101	CGDVADP	FEAT_MTE
011	1110	001	CIVAC	-
011	1110	011	CIGVAC	FEAT_MTE
011	1110	101	CIGDVAC	FEAT_MTE

- [<op1>](#) Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the "op1" field.
- [<Cm>](#) Is a name 'Cm', with 'm' in the range 0 to 15, encoded in the "CRm" field.
- [<op2>](#) Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the "op2" field.
- [<Xt>](#) Is the 64-bit name of the general-purpose source register, encoded in the "Rt" field.



## Operation

The description of [SYS](#) gives the operational pseudocode for this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

DCPS1

- Debug Change PE State to EL1, when executed in Debug state:
- If executed at EL0 changes the current Exception level and SP to EL1 using SP\_EL1.
  - Otherwise, if executed at ELx, selects SP\_ELx.

The target exception level of a DCPS1 instruction is:

- EL1 if the instruction is executed at EL0.
- Otherwise, the Exception level at which the instruction is executed.

When the target Exception level of a DCPS1 instruction is ELx, on executing this instruction:

- *ELR\_ELx* becomes UNKNOWN.
- *SPSR\_ELx* becomes UNKNOWN.
- *ESR\_ELx* becomes UNKNOWN.
- *DLR\_EL0* and *DSPSR\_EL0* become UNKNOWN.
- The endianness is set according to *SCTLR\_ELx*.EE.

This instruction is UNDEFINED at EL0 in Non-secure state if EL2 is implemented and *HCR\_EL2*.TGE == 1.  
This instruction is always UNDEFINED in Non-debug state.  
For more information on the operation of the DCPSn instructions, see *DCPS*.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	0	1	0	1	imm16																0	0	0	0	1
LL																															

DCPS1 {#<imm>}

if !Halted() then UNDEFINED;

Assembler Symbols

<imm> Is an optional 16-bit unsigned immediate, in the range 0 to 65535, defaulting to 0 and encoded in the "imm16" field.

Operation

DCPSInstruction(LL);

DCPS2

- Debug Change PE State to EL2, when executed in Debug state:
- If executed at EL0 or EL1 changes the current Exception level and SP to EL2 using SP\_EL2.
  - Otherwise, if executed at ELx, selects SP\_ELx.

- The target exception level of a DCPS2 instruction is:
- EL2 if the instruction is executed at an exception level that is not EL3.
  - EL3 if the instruction is executed at EL3.

- When the target Exception level of a DCPS2 instruction is ELx, on executing this instruction:
- *ELR\_ELx* becomes UNKNOWN.
  - *SPSR\_ELx* becomes UNKNOWN.
  - *ESR\_ELx* becomes UNKNOWN.
  - *DLR\_EL0* and *DSPSR\_EL0* become UNKNOWN.
  - The endianness is set according to *SCTLR\_ELx*.EE.

- This instruction is UNDEFINED at the following exception levels:
- All exception levels if EL2 is not implemented.
  - At EL0 and EL1 if EL2 is disabled in the current Security state.

This instruction is always UNDEFINED in Non-debug state.  
For more information on the operation of the DCPSn instructions, see *DCPS*.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	0	1	0	1	imm16																0	0	0	1	0
LL																															

DCPS2 {#<imm>}

```
if !Halted() then UNDEFINED;
```

Assembler Symbols

<imm> Is an optional 16-bit unsigned immediate, in the range 0 to 65535, defaulting to 0 and encoded in the "imm16" field.

Operation

```
DCPSInstruction(LL);
```

DCPS3

- Debug Change PE State to EL3, when executed in Debug state:
- If executed at EL3 selects SP\_EL3.
  - Otherwise, changes the current Exception level and SP to EL3 using SP\_EL3.

The target exception level of a DCPS3 instruction is EL3.

- On executing a DCPS3 instruction:
- *ELR\_EL3* becomes UNKNOWN.
  - *SPSR\_EL3* becomes UNKNOWN.
  - *ESR\_EL3* becomes UNKNOWN.
  - *DLR\_EL0* and *DSPSR\_EL0* become UNKNOWN.
  - The endianness is set according to *SCTLR\_EL3*.EE.

- This instruction is UNDEFINED at all exception levels if either:
- *EDSCR*.SDD == 1.
  - EL3 is not implemented.

This instruction is always UNDEFINED in Non-debug state.  
For more information on the operation of the DCPSn instructions, see *DCPS*.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	0	1	0	1	imm16																0	0	0	1	1
LL																															

DCPS3 {#<imm>}

if !Halted() then UNDEFINED;

Assembler Symbols

<imm> Is an optional 16-bit unsigned immediate, in the range 0 to 65535, defaulting to 0 and encoded in the "imm16" field.

Operation

DCPSInstruction(LL);

# DGH

DGH is a hint instruction. A DGH instruction is not expected to be performance optimal to merge memory accesses with Normal Non-cacheable or Device-GRE attributes appearing in program order before the hint instruction with any memory accesses appearing after the hint instruction into a single memory transaction on an interconnect.

## System (FEAT\_DGH)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	1	1	0	1	1	1	1	1
																CRm				op2											

## DGH

```
if !HaveDGHExt() then EndOfInstruction();
```

## Operation

```
Hint_DGH();
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41  
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# DMB

Data Memory Barrier is a memory barrier that ensures the ordering of observations of memory accesses, see [Data Memory Barrier](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	1	CRm			1	0	1	1	1	1	1	1	1
opc																															

DMB <option>|<#imm>

```
case CRm<3:2> of
  when '00' domain = MBReqDomain_OuterShareable;
  when '01' domain = MBReqDomain_Nonshareable;
  when '10' domain = MBReqDomain_InnerShareable;
  when '11' domain = MBReqDomain_FullSystem;
case CRm<1:0> of
  when '00' types = MBReqTypes_All; domain = MBReqDomain_FullSystem;
  when '01' types = MBReqTypes_Reads;
  when '10' types = MBReqTypes_Writes;
  when '11' types = MBReqTypes_All;
```

## Assembler Symbols

- <option> Specifies the limitation on the barrier operation. Values are:
- SY

Full system is the required shareability domain, reads and writes are the required access types, both before and after the barrier instruction. This option is referred to as the full system barrier. Encoded as CRm = 0b1111.
- ST

Full system is the required shareability domain, writes are the required access type, both before and after the barrier instruction. Encoded as CRm = 0b1110.
- LD

Full system is the required shareability domain, reads are the required access type before the barrier instruction, and reads and writes are the required access types after the barrier instruction. Encoded as CRm = 0b1101.
- ISH

Inner Shareable is the required shareability domain, reads and writes are the required access types, both before and after the barrier instruction. Encoded as CRm = 0b1011.
- ISHST

Inner Shareable is the required shareability domain, writes are the required access type, both before and after the barrier instruction. Encoded as CRm = 0b1010.
- ISHLD

Inner Shareable is the required shareability domain, reads are the required access type before the barrier instruction, and reads and writes are the required access types after the barrier instruction. Encoded as CRm = 0b1001.
- NSH

Non-shareable is the required shareability domain, reads and writes are the required access, both before and after the barrier instruction. Encoded as CRm = 0b0111.
- NSHST

Non-shareable is the required shareability domain, writes are the required access type, both before and after the barrier instruction. Encoded as CRm = 0b0110.
- NSHLD

Non-shareable is the required shareability domain, reads are the required access type before the barrier instruction, and reads and writes are the required access types after the barrier instruction. Encoded as CRm = 0b0101.

**OSH**

Outer Shareable is the required shareability domain, reads and writes are the required access types, both before and after the barrier instruction. Encoded as CRm = 0b0011.

**OSHST**

Outer Shareable is the required shareability domain, writes are the required access type, both before and after the barrier instruction. Encoded as CRm = 0b0010.

**OSHL**

Outer Shareable is the required shareability domain, reads are the required access type before the barrier instruction, and reads and writes are the required access types after the barrier instruction. Encoded as CRm = 0b0001.

All other encodings of CRm that are not listed above are reserved, and can be encoded using the #<imm> syntax. All unsupported and reserved options must execute as a full system barrier operation, but software must not rely on this behavior. For more information on whether an access is before or after a barrier instruction, see *Data Memory Barrier (DMB)* or see *Data Synchronization Barrier (DSB)*.

<imm>

Is a 4-bit unsigned immediate, in the range 0 to 15, encoded in the "CRm" field.

**Operation**

```
DataMemoryBarrier(domain, types);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

DRPS

Debug restore process state

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	1	0	1	0	1	1	1	1	1	1	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0

DRPS

```
if !Halted() || PSTATE.EL == EL0 then UNDEFINED;
```

Operation

```
DRPSInstruction();
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41  
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



## DSB

Data Synchronization Barrier is a memory barrier that ensures the completion of memory accesses, see [Data Synchronization Barrier](#).

A DSB instruction with the nXS qualifier is complete when the subset of these memory accesses with the XS attribute set to 0 are complete. It does not require that memory accesses with the XS attribute set to 1 are complete.

This instruction is used by the aliases [PSSBB](#), and [SSBB](#).

It has encodings from 2 classes: [Memory barrier](#) and [Memory nXS barrier](#)

### Memory barrier

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	1	CRm			1	0	0	1	1	1	1	1	
																											opc				

DSB <option>|#<imm>

```
boolean nXS = FALSE;

case CRm<3:2> of
  when '00' domain = MBReqDomain\_OuterShareable;
  when '01' domain = MBReqDomain\_Nonshareable;
  when '10' domain = MBReqDomain\_InnerShareable;
  when '11' domain = MBReqDomain\_FullSystem;
case CRm<1:0> of
  when '00' types = MBReqTypes\_All; domain = MBReqDomain\_FullSystem;
  when '01' types = MBReqTypes\_Reads;
  when '10' types = MBReqTypes\_Writes;
  when '11' types = MBReqTypes\_All;
```

### Memory nXS barrier (FEAT\_XS)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	1	imm2	1	0	0	0	1	1	1	1	1	1	

DSB <option>nXS|#<imm>

```
if !HaveFeatXS() then UNDEFINED;
MBReqTypes types = MBReqTypes\_All;
boolean nXS = TRUE;

case imm2 of
  when '00' domain = MBReqDomain\_OuterShareable;
  when '01' domain = MBReqDomain\_Nonshareable;
  when '10' domain = MBReqDomain\_InnerShareable;
  when '11' domain = MBReqDomain\_FullSystem;
```

### Assembler Symbols

- <option> For the memory barrier variant: specifies the limitation on the barrier operation. Values are:
- SY** Full system is the required shareability domain, reads and writes are the required access types, both before and after the barrier instruction. This option is referred to as the full system barrier. Encoded as CRm = 0b1111.
  - ST** Full system is the required shareability domain, writes are the required access type, both before and after the barrier instruction. Encoded as CRm = 0b1110.

**LD**

Full system is the required shareability domain, reads are the required access type before the barrier instruction, and reads and writes are the required access types after the barrier instruction. Encoded as CRm = 0b1101.

**ISH**

Inner Shareable is the required shareability domain, reads and writes are the required access types, both before and after the barrier instruction. Encoded as CRm = 0b1011.

**ISHST**

Inner Shareable is the required shareability domain, writes are the required access type, both before and after the barrier instruction. Encoded as CRm = 0b1010.

**ISHLD**

Inner Shareable is the required shareability domain, reads are the required access type before the barrier instruction, and reads and writes are the required access types after the barrier instruction. Encoded as CRm = 0b1001.

**NSH**

Non-shareable is the required shareability domain, reads and writes are the required access, both before and after the barrier instruction. Encoded as CRm = 0b0111.

**NSHST**

Non-shareable is the required shareability domain, writes are the required access type, both before and after the barrier instruction. Encoded as CRm = 0b0110.

**NSHLD**

Non-shareable is the required shareability domain, reads are the required access type before the barrier instruction, and reads and writes are the required access types after the barrier instruction. Encoded as CRm = 0b0101.

**OSH**

Outer Shareable is the required shareability domain, reads and writes are the required access types, both before and after the barrier instruction. Encoded as CRm = 0b0011.

**OSHST**

Outer Shareable is the required shareability domain, writes are the required access type, both before and after the barrier instruction. Encoded as CRm = 0b0010.

**OSHLD**

Outer Shareable is the required shareability domain, reads are the required access type before the barrier instruction, and reads and writes are the required access types after the barrier instruction. Encoded as CRm = 0b0001.

All other encodings of CRm, other than the values 0b0000 and 0b0100, that are not listed above are reserved, and can be encoded using the #<imm> syntax. All unsupported and reserved options must execute as a full system barrier operation, but software must not rely on this behavior. For more information on whether an access is before or after a barrier instruction, see [Data Memory Barrier \(DMB\)](#) or see [Data Synchronization Barrier \(DSB\)](#).

The value 0b0000 is used to encode SSBB and the value 0b0100 is used to encode PSSBB.

For the memory nXS barrier variant: specifies the limitation on the barrier operation. Values are:

**SY**

Full system is the required shareability domain, reads and writes are the required access types, both before and after the barrier instruction. This option is referred to as the full system barrier. Encoded as CRm<3:2> = 0b11.

**ISH**

Inner Shareable is the required shareability domain, reads and writes are the required access types, both before and after the barrier instruction. Encoded as CRm<3:2> = 0b10.

**NSH**

Non-shareable is the required shareability domain, reads and writes are the required access, both before and after the barrier instruction. Encoded as CRm<3:2> = 0b01.

**OSH**

Outer Shareable is the required shareability domain, reads and writes are the required access types, both before and after the barrier instruction. Encoded as CRm<3:2> = 0b00.

<imm>

For the memory barrier variant: is a 4-bit unsigned immediate, in the range 0 to 15, encoded in the "CRm" field.

For the memory nXS barrier variant: is a 5-bit unsigned immediate, encoded in “imm2”:

imm2	<imm>
00	16
01	20
10	24
11	28

## Alias Conditions

Alias	Is preferred when
<a href="#">PSSBB</a>	CRm == '0100'
<a href="#">SSBB</a>	CRm == '0000'

## Operation

```
if !nXS && HaveFeatXS() && HaveFeatHCX() then
    nXS = PSTATE.EL IN {EL0, EL1} && IsHCRXEL2Enabled() && HCRX_EL2.FnXS == '1';
DataSynchronizationBarrier(domain, types, nXS);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# DVP

Data Value Prediction Restriction by Context prevents data value predictions that predict execution addresses based on information gathered from earlier execution within a particular execution context. Data value predictions determined by the actions of code in the target execution context or contexts appearing in program order before the instruction cannot be used to exploitatively control speculative execution occurring after the instruction is complete and synchronized.

For more information, see *DVP RCTX, Data Value Prediction Restriction by Context*.

This is an alias of [SYS](#). This means:

- The encodings in this description are named to match the encodings of [SYS](#).
- The description of [SYS](#) gives the operational pseudocode for this instruction.

## System

(FEAT\_SPECRES)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	1	0	1	1	0	1	1	1	0	0	1	1	1	0	1					Rt
										L			op1			CRn				CRm				op2							

DVP RCTX, [<Xt>](#)

is equivalent to

[SYS](#) #3, C7, C3, #5, [<Xt>](#)

and is always the preferred disassembly.

## Assembler Symbols

[<Xt>](#) Is the 64-bit name of the general-purpose source register, encoded in the "Rt" field.

## Operation

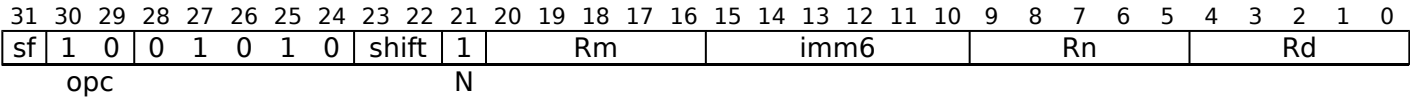
The description of [SYS](#) gives the operational pseudocode for this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## EON (shifted register)

Bitwise Exclusive OR NOT (shifted register) performs a bitwise Exclusive OR NOT of a register value and an optionally-shifted register value, and writes the result to the destination register.



### 32-bit (sf == 0)

EON <Wd>, <Wn>, <Wm>{, <shift> #<amount>}

### 64-bit (sf == 1)

EON <Xd>, <Xn>, <Xm>{, <shift> #<amount>}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
if sf == '0' && imm6<5> == '1' then UNDEFINED;

ShiftType shift_type = DecodeShift(shift);
integer shift_amount = UInt(imm6);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <shift> Is the optional shift to be applied to the final source, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	ROR
- <amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.  
For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field,

## Operation

```
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = ShiftReg(m, shift_type, shift_amount);

operand2 = NOT(operand2);

result = operand1 EOR operand2;

X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

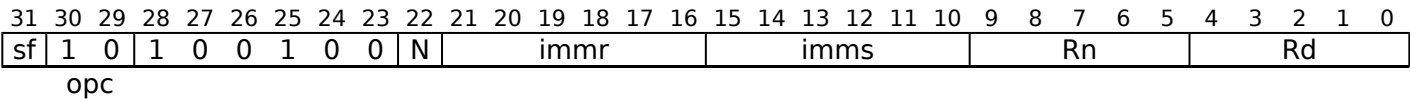
- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# EOR (immediate)

Bitwise Exclusive OR (immediate) performs a bitwise Exclusive OR of a register value and an immediate value, and writes the result to the destination register.



## 32-bit (sf == 0 && N == 0)

EOR <Wd|WSP>, <Wn>, #<imm>

## 64-bit (sf == 1)

EOR <Xd|SP>, <Xn>, #<imm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer datasize = if sf == '1' then 64 else 32;
bits(datasize) imm;
if sf == '0' && N != '0' then UNDEFINED;
(imm, -) = DecodeBitMasks(N, imms, immr, TRUE);
```

## Assembler Symbols

- <Wd|WSP> Is the 32-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
- <Xd|SP> Is the 64-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
- <imm> For the 32-bit variant: is the bitmask immediate, encoded in "imms:immr".  
For the 64-bit variant: is the bitmask immediate, encoded in "N:imms:immr".

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = X[n];

result = operand1 EOR imm;

if d == 31 then
    SP[] = result;
else
    X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

## EOR (shifted register)

Bitwise Exclusive OR (shifted register) performs a bitwise Exclusive OR of a register value and an optionally-shifted register value, and writes the result to the destination register.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
sf	1	0	0	1	0	1	0	shift	0	Rm						imm6						Rn						Rd							
opc								N																											

### 32-bit (sf == 0)

EOR <Wd>, <Wn>, <Wm>{, <shift> #<amount>}

### 64-bit (sf == 1)

EOR <Xd>, <Xn>, <Xm>{, <shift> #<amount>}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
if sf == '0' && imm6<5> == '1' then UNDEFINED;

ShiftType shift_type = DecodeShift(shift);
integer shift_amount = UInt(imm6);
```

## Assembler Symbols

- <Wd>

Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn>

Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm>

Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd>

Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn>

Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm>

Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <shift>

Is the optional shift to be applied to the final source, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	ROR
- <amount>

For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.  
  
For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field,

## Operation

```
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = ShiftReg(m, shift_type, shift_amount);

result = operand1 EOR operand2;

X[d] = result;
```



## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

ERET

Exception Return using the ELR and SPSR for the current Exception level. When executed, the PE restores *PSTATE* from the SPSR, and branches to the address held in the ELR.

The PE checks the SPSR for the current Exception level for an illegal return event. See *Illegal return events from AArch64 state*.

ERET is UNDEFINED at EL0.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0								
1	1	0	1	0	1	1	0	1	0	0	1	1	1	1	1	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0								
																					A		M									Rn				op4			

ERET

```
if PSTATE.EL == EL0 then UNDEFINED;
```

Operation

```
AArch64.CheckForERetTrap(FALSE, TRUE);
bits(64) target = ELR[];

AArch64.ExceptionReturn(target, SPSR[]);
```

# ERETAA, ERETAB

Exception Return, with pointer authentication. This instruction authenticates the address in ELR, using SP as the modifier and the specified key, the PE restores *PSTATE* from the SPSR for the current Exception level, and branches to the authenticated address.

Key A is used for ERETAA, and key B is used for ERETAB.

If the authentication passes, the PE continues execution at the target of the branch. If the authentication fails, a Translation fault is generated.

The authenticated address is not written back to ELR.

The PE checks the SPSR for the current Exception level for an illegal return event. See *Illegal return events from AArch64 state*.

ERETAA and ERETAB are UNDEFINED at EL0.

## Integer (FEAT\_PAuth)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	1	0	1	0	0	1	1	1	1	1	0	0	0	0	1	M	1	1	1	1	1	1	1	1	1	1
A																					Rn					op4					

### ERETAA (M == 0)

ERETAA

### ERETAB (M == 1)

ERETAB

```
if PSTATE.EL == EL0 then UNDEFINED;
boolean use_key_a = (M == '0');

if !HavePACExt() then
    UNDEFINED;
```

## Operation

```
AArch64.CheckForERetTrap(TRUE, use_key_a);
bits(64) target;

if use_key_a then
    target = AuthIA(ELR[], SP[], TRUE);
else
    target = AuthIB(ELR[], SP[], TRUE);

AArch64.ExceptionReturn(target, SPSR[]);
```

ESB

Error Synchronization Barrier is an error synchronization event that might also update DISR\_EL1 and VDISR\_EL2. This instruction can be used at all Exception levels and in Debug state.

In Debug state, this instruction behaves as if SError interrupts are masked at all Exception levels. See Error Synchronization Barrier in the Arm(R) Reliability, Availability, and Serviceability (RAS) Specification, Armv8, for Armv8-A architecture profile.

If the RAS Extension is not implemented, this instruction executes as a NOP.

System  
(FEAT\_RAS)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	1	0	0	0	0	1	1	1	1	1
																CRm				op2											

ESB

```
if !HaveRASExt() then EndOfInstruction();
```

Operation

```
SynchronizeErrors();
AArch64.ESB0operation();
if PSTATE.EL IN {EL0, EL1} && EL2Enabled() then AArch64.vESB0operation();
TakeUnmaskedSErrorInterrupts();
```

# EXTR

Extract register extracts a register from a pair of registers.

This instruction is used by the alias [ROR \(immediate\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	0	1	0	0	1	1	1	N	0	Rm					imms					Rn					Rd					

**32-bit (sf == 0 && N == 0 && imms == 0xxxxx)**

EXTR <Wd>, <Wn>, <Wm>, #<lsb>

**64-bit (sf == 1 && N == 1)**

EXTR <Xd>, <Xn>, <Xm>, #<lsb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
integer lsb;

if N != sf then UNDEFINED;
if sf == '0' && imms<5> == '1' then UNDEFINED;
lsb = UInt(imms);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <lsb> For the 32-bit variant: is the least significant bit position from which to extract, in the range 0 to 31, encoded in the "imms" field.  
For the 64-bit variant: is the least significant bit position from which to extract, in the range 0 to 63, encoded in the "imms" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">ROR (immediate)</a>	Rn == Rm

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = X[m];
bits(2*datasize) concat = operand1:operand2;

result = concat<lsb+datasize-1:lsb>;

X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

GMI

Tag Mask Insert inserts the tag in the first source register into the excluded set specified in the second source register, writing the new excluded set to the destination register.

Integer  
(FEAT\_MTE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	1	0	1	0	1	1	0	Xm					0	0	0	1	0	1	Xn					Xd				

GMI <Xd>, <Xn|SP>, <Xm>

```
if !HaveMTEExt() then UNDEFINED;
integer d = UInt(Xd);
integer n = UInt(Xn);
integer m = UInt(Xm);
```

Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Xd" field.
- <Xn|SP> Is the 64-bit name of the first source general-purpose register or stack pointer, encoded in the "Xn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Xm" field.

Operation

```
bits(64) address = if n == 31 then SP[] else X[n];
bits(64) mask = X[m];
bits(4) tag = AArch64.AllocationTagFromAddress(address);

mask<UInt(tag)> = '1';
X[d] = mask;
```

# HINT

Hint instruction is for the instruction set space that is reserved for architectural hint instructions. Some encodings described here are not allocated in this revision of the architecture, and behave as NOPs. These encodings might be allocated to other hint functionality in future revisions of the architecture and therefore must not be used by software.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	CRm			op2			1	1	1	1	1	1

HINT #<imm>

```
SystemHintOp op;

case CRm:op2 of
  when '0000 000' op = SystemHintOp_NOP;
  when '0000 001' op = SystemHintOp_YIELD;
  when '0000 010' op = SystemHintOp_WFE;
  when '0000 011' op = SystemHintOp_WFI;
  when '0000 100' op = SystemHintOp_SEV;
  when '0000 101' op = SystemHintOp_SEVL;
  when '0000 110'
    if !HaveDGHExt() then EndOfInstruction(); // Instruction executes as NOP
    op = SystemHintOp_DGH;
  when '0000 111' SEE "XPACLRI";
  when '0001 xxx'
    case op2 of
      when '000' SEE "PACIA1716";
      when '010' SEE "PACIB1716";
      when '100' SEE "AUTIA1716";
      when '110' SEE "AUTIB1716";
      otherwise EndOfInstruction();
  when '0010 000'
    if !HaveRASExt() then EndOfInstruction(); // Instruction executes as NOP
    op = SystemHintOp_ESB;
  when '0010 001'
    if !HaveStatisticalProfiling() then EndOfInstruction(); // Instruction executes as NOP
    op = SystemHintOp_PSB;
  when '0010 010'
    if !HaveSelfHostedTrace() then EndOfInstruction(); // Instruction executes as NOP
    op = SystemHintOp_TSB;
  when '0010 100'
    op = SystemHintOp_CSDB;
  when '0011 xxx'
    case op2 of
      when '000' SEE "PACIAZ";
      when '001' SEE "PACIASP";
      when '010' SEE "PACIBZ";
      when '011' SEE "PACIBSP";
      when '100' SEE "AUTIAZ";
      when '101' SEE "AUTHASP";
      when '110' SEE "AUTIBZ";
      when '111' SEE "AUTIBSP";
  when '0100 xx0'
    op = SystemHintOp_BTI;
    // Check branch target compatibility between BTI instruction and PSTATE.BTYPE
    SetBTypeCompatible(BTypeCompatible_BTI(op2<2:1>));
  otherwise EndOfInstruction();
```

## Assembler Symbols

- <imm> Is a 7-bit unsigned immediate, in the range 0 to 127 encoded in the "CRm:op2" field. The encodings that are allocated to architectural hint functionality are described in the "Hints" table in the "Index by Encoding". For allocated encodings of "CRm:op2":



- A disassembler will disassemble the allocated instruction, rather than the HINT instruction.
- An assembler may support assembly of allocated encodings using HINT with the corresponding <imm> value, but it is not required to do so.

## Operation

```

case op of
  when SystemHintOp\_YIELD
    Hint\_Yield\(\);

  when SystemHintOp\_DGH
    Hint\_DGH\(\);

  when SystemHintOp\_WFE
    Hint\_WFE(-1, WFXType\_WFE);

  when SystemHintOp\_WFI
    Hint\_WFI(-1, WFXType\_WFI);

  when SystemHintOp\_SEV
    SendEvent();

  when SystemHintOp\_SEVL
    SendEventLocal();

  when SystemHintOp\_ESB
    SynchronizeErrors();
    AArch64.ESB0operation();
    if PSTATE.EL IN {EL0, EL1} && EL2Enabled() then AArch64.vESB0operation();
    TakeUnmaskedSErrorInterrupts();

  when SystemHintOp\_PSB
    ProfilingSynchronizationBarrier();

  when SystemHintOp\_TSB
    TraceSynchronizationBarrier();

  when SystemHintOp\_CSDB
    ConsumptionOfSpeculativeDataBarrier();

  when SystemHintOp\_BTI
    SetBTypeNext('00');

  otherwise    // do nothing

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# HLT

Halt instruction. An HLT instruction can generate a Halt Instruction debug event, which causes entry into Debug state.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	0	0	1	0	imm16																0	0	0	0	0

HLT #<imm>

```
if EDSCR.HDE == '0' || !HaltingAllowed() then UNDEFINED;
if HaveBTIExt() then
    SetBTypeCompatible(TRUE);
```

## Assembler Symbols

<imm> Is a 16-bit unsigned immediate, in the range 0 to 65535, encoded in the "imm16" field.

## Operation

```
Halt(DebugHalt_HaltInstruction);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41  
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# HVC

Hypervisor Call causes an exception to EL2. Non-secure software executing at EL1 can use this instruction to call the hypervisor to request a service.

The HVC instruction is UNDEFINED:

- At EL0.
- At EL1 if EL2 is not enabled in the current Security state.
- When [SCR\\_EL3.HCE](#) is set to 0.

On executing an HVC instruction, the PE records the exception as a Hypervisor Call exception in [ESR\\_ELx](#), using the EC value 0x16, and the value of the immediate argument.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	0	0	0	0	imm16																0	0	0	1	0

HVC #<imm>

// Empty.

## Assembler Symbols

<imm> Is a 16-bit unsigned immediate, in the range 0 to 65535, encoded in the "imm16" field.

## Operation

```
if !HaveEL(EL2) || PSTATE.EL == EL0 || (PSTATE.EL == EL1 && (!IsSecureEL2Enabled() && IsSecure())) then
    UNDEFINED;

hvc_enable = if HaveEL(EL3) then SCR_EL3.HCE else NOT(HCR_EL2.HCD);

if hvc_enable == '0' then
    UNDEFINED;
else
    AArch64.CallHypervisor(imm16);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

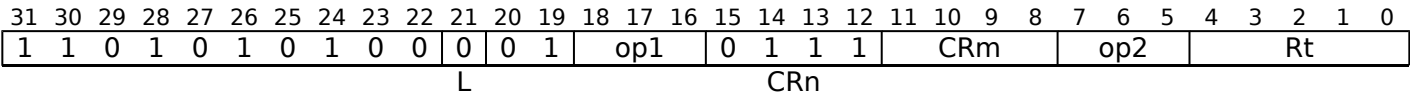
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

IC

Instruction Cache operation. For more information, see *op0==0b01, cache maintenance, TLB maintenance, and address translation instructions*.

This is an alias of [SYS](#). This means:

- The encodings in this description are named to match the encodings of [SYS](#).
- The description of [SYS](#) gives the operational pseudocode for this instruction.



IC [<ic\\_op>](#){, [<Xt>](#)}

is equivalent to

[SYS](#) #[<op1>](#), C7, [<Cm>](#), #[<op2>](#){, [<Xt>](#)}

and is the preferred disassembly when `SysOp(op1, '0111', CRm, op2) == Sys_IC`.

Assembler Symbols

[<ic\\_op>](#) Is an IC instruction name, as listed for the IC system instruction pages, encoded in “[op1](#):[CRm](#):[op2](#)”:

op1	CRm	op2	<ic_op>
000	0001	000	IALLUIS
000	0101	000	IALLU
011	0101	001	IVAU

- [<op1>](#) Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the “[op1](#)” field.
- [<Cm>](#) Is a name 'Cm', with 'm' in the range 0 to 15, encoded in the “[CRm](#)” field.
- [<op2>](#) Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the “[op2](#)” field.
- [<Xt>](#) Is the 64-bit name of the optional general-purpose source register, defaulting to '11111', encoded in the “[Rt](#)” field.

Operation

The description of [SYS](#) gives the operational pseudocode for this instruction.

## IRG

Insert Random Tag inserts a random Logical Address Tag into the address in the first source register, and writes the result to the destination register. Any tags specified in the optional second source register or in GCR\_EL1.Exclude are excluded from the selection of the random Logical Address Tag.

### Integer (FEAT\_MTE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	1	0	1	0	1	1	0	Xm				0	0	0	1	0	0	Xn				Xd						

IRG <Xd|SP>, <Xn|SP>{, <Xm>}

```
if !HaveMTEExt() then UNDEFINED;
integer d = UInt(Xd);
integer n = UInt(Xn);
integer m = UInt(Xm);
```

### Assembler Symbols

- <Xd|SP> Is the 64-bit name of the destination general-purpose register or stack pointer, encoded in the "Xd" field.
- <Xn|SP> Is the 64-bit name of the first source general-purpose register or stack pointer, encoded in the "Xn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Xm" field. Defaults to XZR if absent.

### Operation

```
bits(64) operand = if n == 31 then SP[] else X[n];
bits(64) exclude_reg = X[m];
bits(16) exclude = exclude_reg<15:0> OR GCR_EL1.Exclude;

if AArch64.AllocationTagAccessIsEnabled(AccType_NORMAL) then
    if GCR_EL1.RRND == '1' then
        RGSR_EL1 = bits(64) UNKNOWN;
        if IsOnes(exclude) then
            rtag = '0000';
        else
            rtag = ChooseRandomNonExcludedTag(exclude);
    else
        bits(4) start = RGSR_EL1.TAG;
        bits(4) offset = AArch64.RandomTag();

        rtag = AArch64.ChooseNonExcludedTag(start, offset, exclude);

        RGSR_EL1.TAG = rtag;
else
    rtag = '0000';

bits(64) result = AArch64.AddressWithAllocationTag(operand, AccType_NORMAL, rtag);

if d == 31 then
    SP[] = result;
else
    X[d] = result;
```

# ISB

Instruction Synchronization Barrier flushes the pipeline in the PE and is a context synchronization event. For more information, see [Instruction Synchronization Barrier \(ISB\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	1	CRm			1	1	0	1	1	1	1	1	1
opc																															

ISB {<option>|<imm>}

// No additional decoding required

## Assembler Symbols

- <option>

Specifies an optional limitation on the barrier operation. Values are:  
**SY**  
Full system barrier operation, encoded as CRm = 0b1111. Can be omitted.  
  
All other encodings of CRm are reserved. The corresponding instructions execute as full system barrier operations, but must not be relied upon by software.
- <imm>

Is an optional 4-bit unsigned immediate, in the range 0 to 15, defaulting to 15 and encoded in the "CRm" field.

## Operation

[InstructionSynchronizationBarrier\(\)](#);

LD64B

Single-copy Atomic 64-byte Load derives an address from a base register value, loads eight 64-bit doublewords from a memory location, and writes them to consecutive registers, Xt to X(t+7). The data that is loaded is atomic and is required to be 64-byte aligned.

Integer  
(FEAT\_LS64)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	1	1	1	0	1	0	0	Rn				Rt					

LD64B <Xt>, [<Xn|SP> {, #0}]

```
if !HaveFeatLS64() then UNDEFINED;
if Rt<4:3> == '11' || Rt<0> == '1' then UNDEFINED;

integer n = UInt(Rn);
integer t = UInt(Rt);
boolean tag_checked = n != 31;
```

Assembler Symbols

- <Xt> Is the 64-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Operation

```
CheckLDST64BEnabled();

bits(512) data;
bits(64) address;
bits(64) value;
acctype = AccType_ATOMICLS64;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemLoad64B(address, acctype);

for i = 0 to 7
    value = data<63+64*i:64*i>;
    if BigEndian(acctype) then value = BigEndianReverse(value);
    X[t+i] = value;
```

# LDADD, LDADDA, LDADDAL, LDADDL

Atomic add on word or doubleword in memory atomically loads a 32-bit word or 64-bit doubleword from memory, adds the value held in a register to it, and stores the result back to memory. The value initially loaded from memory is returned in the destination register.

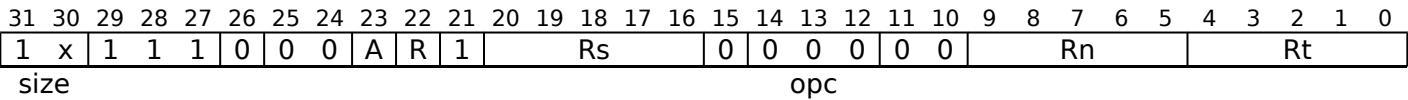
- If the destination register is not one of WZR or XZR, LDADDA and LDADDAL load from memory with acquire semantics.
- LDADDL and LDADDAL store to memory with release semantics.
- LDADD has neither acquire nor release semantics.

For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This instruction is used by the alias *STADD, STADDL*.

## Integer (FEAT\_LSE)





32-bit LDADD (size == 10 && A == 0 && R == 0)

```
LDADD <Ws>, <Wt>, [<Xn|SP>]
```

32-bit LDADDA (size == 10 && A == 1 && R == 0)

```
LDADDA <Ws>, <Wt>, [<Xn|SP>]
```

32-bit LDADDAL (size == 10 && A == 1 && R == 1)

```
LDADDAL <Ws>, <Wt>, [<Xn|SP>]
```

32-bit LDADDL (size == 10 && A == 0 && R == 1)

```
LDADDL <Ws>, <Wt>, [<Xn|SP>]
```

64-bit LDADD (size == 11 && A == 0 && R == 0)

```
LDADD <Xs>, <Xt>, [<Xn|SP>]
```

64-bit LDADDA (size == 11 && A == 1 && R == 0)

```
LDADDA <Xs>, <Xt>, [<Xn|SP>]
```

64-bit LDADDAL (size == 11 && A == 1 && R == 1)

```
LDADDAL <Xs>, <Xt>, [<Xn|SP>]
```

64-bit LDADDL (size == 11 && A == 0 && R == 1)

```
LDADDL <Xs>, <Xt>, [<Xn|SP>]
```

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

integer datasize = 8 << UInt(size);
integer regsize = if datasize == 64 then 64 else 32;
AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

Assembler Symbols

<Ws>	Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Wt>	Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
<Xs>	Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xt>	Is the 64-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Alias Conditions

Alias	Is preferred when
<a href="#">STADD, STADDL</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(datasize) value;
bits(datasize) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_ADD, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, regsize);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDADDB, LDADDAB, LDADDALB, LDADDLB

Atomic add on byte in memory atomically loads an 8-bit byte from memory, adds the value held in a register to it, and stores the result back to memory. The value initially loaded from memory is returned in the destination register.

- If the destination register is not WZR, LDADDAB and LDADDALB load from memory with acquire semantics.
- LDADDLB and LDADDALB store to memory with release semantics.
- LDADDB has neither acquire nor release semantics.

For more information about memory ordering semantics see [Load-Acquire, Store-Release](#).

For information about memory accesses see [Load/Store addressing modes](#).

This instruction is used by the alias [STADDB, STADDLB](#).

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	A	R	1	Rs				0	0	0	0	0	0	Rn				Rt						
size											opc																				

### LDADDAB (A == 1 && R == 0)

LDADDAB <Ws>, <Wt>, [<Xn|SP>]

### LDADDALB (A == 1 && R == 1)

LDADDALB <Ws>, <Wt>, [<Xn|SP>]

### LDADDB (A == 0 && R == 0)

LDADDB <Ws>, <Wt>, [<Xn|SP>]

### LDADDLB (A == 0 && R == 1)

LDADDLB <Ws>, <Wt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">STADDB, STADDLB</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(8) value;
bits(8) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_ADD, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDADDH, LDADDAH, LDADDALH, LDADDLH

Atomic add on halfword in memory atomically loads a 16-bit halfword from memory, adds the value held in a register to it, and stores the result back to memory. The value initially loaded from memory is returned in the destination register.

- If the destination register is not WZR, LDADDAH and LDADDALH load from memory with acquire semantics.
- LDADDLH and LDADDALH store to memory with release semantics.
- LDADDH has neither acquire nor release semantics.

For more information about memory ordering semantics see [Load-Acquire, Store-Release](#).

For information about memory accesses see [Load/Store addressing modes](#).

This instruction is used by the alias [STADDH, STADDLH](#).

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	A	R	1	Rs				0	0	0	0	0	0	Rn				Rt						
size											opc																				

### LDADDAH (A == 1 && R == 0)

LDADDAH <Ws>, <Wt>, [<Xn|SP>]

### LDADDALH (A == 1 && R == 1)

LDADDALH <Ws>, <Wt>, [<Xn|SP>]

### LDADDH (A == 0 && R == 0)

LDADDH <Ws>, <Wt>, [<Xn|SP>]

### LDADDLH (A == 0 && R == 1)

LDADDLH <Ws>, <Wt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">STADDH, STADDLH</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(16) value;
bits(16) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_ADD, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDAPR

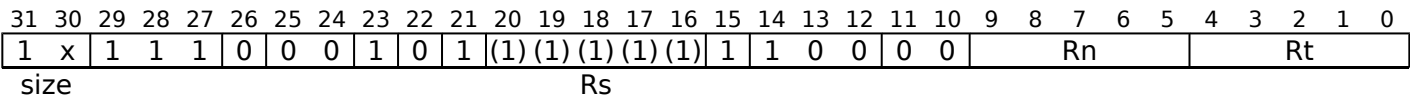
Load-Acquire RCpc Register derives an address from a base register value, loads a 32-bit word or 64-bit doubleword from the derived address in memory, and writes it to a register.

The instruction has memory ordering semantics as described in *Load-Acquire, Load-AcquirePC, and Store-Release*, except that:

- There is no ordering requirement, separate from the requirements of a Load-AcquirePC or a Store-Release, created by having a Store-Release followed by a Load-AcquirePC instruction.
- The reading of a value written by a Store-Release by a Load-AcquirePC instruction by the same observer does not make the write of the Store-Release globally observed.

This difference in memory ordering is not described in the pseudocode.  
For information about memory accesses, see *Load/Store addressing modes*.

## Integer (FEAT\_LRCPC)



### 32-bit (size == 10)

LDAPR <Wt>, [<Xn|SP> {, #0}]

### 64-bit (size == 11)

LDAPR <Xt>, [<Xn|SP> {, #0}]

```
integer n = UInt(Rn);
integer t = UInt(Rt);

integer elsize = 8 << UInt(size);
integer regsize = if elsize == 64 then 64 else 32;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(elsize) data;
constant integer dbytes = elsize DIV 8;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = Mem[address, dbytes, AccType_ORDERED];
X[t] = ZeroExtend(data, regsize);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# LDAPRB

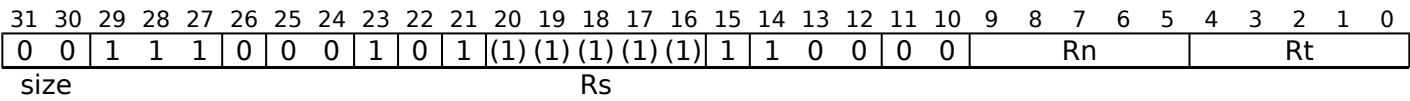
Load-Acquire RCpc Register Byte derives an address from a base register value, loads a byte from the derived address in memory, zero-extends it and writes it to a register.

The instruction has memory ordering semantics as described in *Load-Acquire, Load-AcquirePC, and Store-Release*, except that:

- There is no ordering requirement, separate from the requirements of a Load-AcquirePC or a Store-Release, created by having a Store-Release followed by a Load-AcquirePC instruction.
- The reading of a value written by a Store-Release by a Load-AcquirePC instruction by the same observer does not make the write of the Store-Release globally observed.

This difference in memory ordering is not described in the pseudocode.  
For information about memory accesses, see *Load/Store addressing modes*.

## Integer (FEAT\_LRCPC)



LDAPRB <Wt>, [<Xn|SP> {,#0}]

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(8) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = Mem[address, 1, AccType_ORDERED];
X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDAPRH

Load-Acquire RCpc Register Halfword derives an address from a base register value, loads a halfword from the derived address in memory, zero-extends it and writes it to a register.

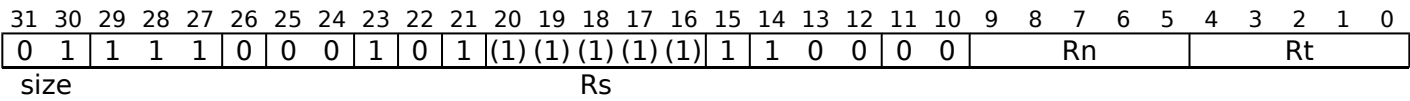
The instruction has memory ordering semantics as described in *Load-Acquire, Load-AcquirePC, and Store-Release*, except that:

- There is no ordering requirement, separate from the requirements of a Load-AcquirePC or a Store-Release, created by having a Store-Release followed by a Load-AcquirePC instruction.
- The reading of a value written by a Store-Release by a Load-AcquirePC instruction by the same observer does not make the write of the Store-Release globally observed.

This difference in memory ordering is not described in the pseudocode.

For information about memory accesses, see *Load/Store addressing modes*.

## Integer (FEAT\_LRCPC)



```
LDAPRH <Wt>, [<Xn|SP> {,#0}]

integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(16) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = Mem[address, 2, AccType_ORDERED];
X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDAPUR

Load-Acquire RCpc Register (unscaled) calculates an address from a base register and an immediate offset, loads a 32-bit word or 64-bit doubleword from memory, zero-extends it, and writes it to a register.

The instruction has memory ordering semantics as described in *Load-Acquire, Load-AcquirePC, and Store-Release*, except that:

- There is no ordering requirement, separate from the requirements of a Load-AcquirePC or a Store-Release, created by having a Store-Release followed by a Load-AcquirePC instruction.
- The reading of a value written by a Store-Release by a Load-AcquirePC instruction by the same observer does not make the write of the Store-Release globally observed.

This difference in memory ordering is not described in the pseudocode.  
For information about memory accesses, see *Load/Store addressing modes*.

## Unscaled offset (FEAT\_LRCPC2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
1	x	0	1	1	0	0	1	0	1	0	imm9									0	0	Rn				Rt									
size										opc																									

### 32-bit (size == 10)

LDAPUR <Wt>, [<Xn|SP>{, #<sim>}]

### 64-bit (size == 11)

LDAPUR <Xt>, [<Xn|SP>{, #<sim>}]

```
integer scale = UInt(size);
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer regsize;

regsize = if size == '11' then 64 else 32;
integer datasize = 8 << scale;
boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(datasize) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = Mem[address, datasize DIV 8, AccType_ORDERED];
X[t] = ZeroExtend(data, regsize);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDAPURB

Load-Acquire RCpc Register Byte (unscaled) calculates an address from a base register and an immediate offset, loads a byte from memory, zero-extends it, and writes it to a register.

The instruction has memory ordering semantics as described in *Load-Acquire, Load-AcquirePC, and Store-Release*, except that:

- There is no ordering requirement, separate from the requirements of a Load-AcquirePC or a Store-Release, created by having a Store-Release followed by a Load-AcquirePC instruction.
- The reading of a value written by a Store-Release by a Load-AcquirePC instruction by the same observer does not make the write of the Store-Release globally observed.

This difference in memory ordering is not described in the pseudocode.  
For information about memory accesses, see *Load/Store addressing modes*.

## Unscaled offset (FEAT\_LRCPC2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1	1	0	0	1	0	1	0	imm9									0	0	Rn				Rt					
size										opc																					

LDAPURB <Wt>, [<Xn|SP>{, #<simm>}]

bits(64) offset = SignExtend(imm9, 64);

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <simm> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(8) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = Mem[address, 1, AccType_ORDERED];
X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.



# LDAPURH

Load-Acquire RCpc Register Halfword (unscaled) calculates an address from a base register and an immediate offset, loads a halfword from memory, zero-extends it, and writes it to a register.

The instruction has memory ordering semantics as described in *Load-Acquire, Load-AcquirePC, and Store-Release*, except that:

- There is no ordering requirement, separate from the requirements of a Load-AcquirePC or a Store-Release, created by having a Store-Release followed by a Load-AcquirePC instruction.
- The reading of a value written by a Store-Release by a Load-AcquirePC instruction by the same observer does not make the write of the Store-Release globally observed.

This difference in memory ordering is not described in the pseudocode.  
For information about memory accesses, see *Load/Store addressing modes*.

## Unscaled offset (FEAT\_LRCPC2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	1	0	imm9									0	0	Rn				Rt					
size										opc																					

LDAPURH <Wt>, [<Xn|SP>{, #<simm>}]

bits(64) offset = SignExtend(imm9, 64);

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <simm> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(16) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = Mem[address, 2, AccType_ORDERED];
X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.





# LDAPURSB

Load-Acquire RCpc Register Signed Byte (unscaled) calculates an address from a base register and an immediate offset, loads a signed byte from memory, sign-extends it, and writes it to a register.

The instruction has memory ordering semantics as described in *Load-Acquire, Load-AcquirePC, and Store-Release*, except that:

- There is no ordering requirement, separate from the requirements of a Load-AcquirePC or a Store-Release, created by having a Store-Release followed by a Load-AcquirePC instruction.
- The reading of a value written by a Store-Release by a Load-AcquirePC instruction by the same observer does not make the write of the Store-Release globally observed.

This difference in memory ordering is not described in the pseudocode.

For information about memory accesses, see *Load/Store addressing modes*.

## Unscaled offset (FEAT\_LRCPC2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
0	0	0	1	1	0	0	1	1	x	0	imm9									0	0	Rn				Rt									
size										opc																									

### 32-bit (opc == 11)

```
LDAPURSB <Wt>, [<Xn|SP>{, #<sim>}]
```

### 64-bit (opc == 10)

```
LDAPURSB <Xt>, [<Xn|SP>{, #<sim>}]

bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

<Wt>	Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
<Xt>	Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<sim>	Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
MemOp memop;
boolean signed;
integer regsize;

if opc<1> == '0' then
    // store or zero-extending load
    memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;
    regsize = 32;
    signed = FALSE;
else
    // sign-extending load
    memop = MemOp_LOAD;
    regsize = if opc<0> == '1' then 32 else 64;
    signed = TRUE;

boolean tag_checked = memop != MemOp_PREFETCH && (n != 31);
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(8) data;

if n == 31 then
    if memop != MemOp_PREFETCH then CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

case memop of
    when MemOp_STORE
        data = X[t];
        Mem[address, 1, AccType_ORDERED] = data;

    when MemOp_LOAD
        data = Mem[address, 1, AccType_ORDERED];
        if signed then
            X[t] = SignExtend(data, regsize);
        else
            X[t] = ZeroExtend(data, regsize);

    when MemOp_PREFETCH
        Prefetch(address, t<4:0>);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDAPURSH

Load-Acquire RCpc Register Signed Halfword (unscaled) calculates an address from a base register and an immediate offset, loads a signed halfword from memory, sign-extends it, and writes it to a register.

The instruction has memory ordering semantics as described in *Load-Acquire, Load-AcquirePC, and Store-Release*, except that:

- There is no ordering requirement, separate from the requirements of a Load-AcquirePC or a Store-Release, created by having a Store-Release followed by a Load-AcquirePC instruction.
- The reading of a value written by a Store-Release by a Load-AcquirePC instruction by the same observer does not make the write of the Store-Release globally observed.

This difference in memory ordering is not described in the pseudocode.  
For information about memory accesses, see *Load/Store addressing modes*.

## Unscaled offset (FEAT\_LRCPC2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
0	1	0	1	1	0	0	1	1	x	0	imm9									0	0	Rn				Rt									
size										opc																									

### 32-bit (opc == 11)

LDAPURSH <Wt>, [<Xn|SP>{, #<sim>}]

### 64-bit (opc == 10)

LDAPURSH <Xt>, [<Xn|SP>{, #<sim>}]

bits(64) offset = [SignExtend](#)(imm9, 64);

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
MemOp memop;
boolean signed;
integer regsize;

if opc<1> == '0' then
    // store or zero-extending load
    memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;
    regsize = 32;
    signed = FALSE;
else
    // sign-extending load
    memop = MemOp_LOAD;
    regsize = if opc<0> == '1' then 32 else 64;
    signed = TRUE;

boolean tag_checked = memop != MemOp_PREFETCH && (n != 31);
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(16) data;

if n == 31 then
    if memop != MemOp_PREFETCH then CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

case memop of
    when MemOp_STORE
        data = X[t];
        Mem[address, 2, AccType_ORDERED] = data;

    when MemOp_LOAD
        data = Mem[address, 2, AccType_ORDERED];
        if signed then
            X[t] = SignExtend(data, regsize);
        else
            X[t] = ZeroExtend(data, regsize);

    when MemOp_PREFETCH
        Prefetch(address, t<4:0>);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDAPURSW

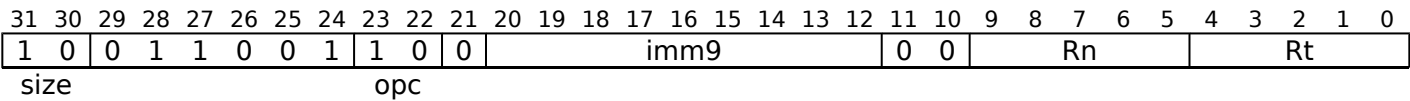
Load-Acquire RCpc Register Signed Word (unscaled) calculates an address from a base register and an immediate offset, loads a signed word from memory, sign-extends it, and writes it to a register.

The instruction has memory ordering semantics as described in *Load-Acquire, Load-AcquirePC, and Store-Release*, except that:

- There is no ordering requirement, separate from the requirements of a Load-AcquirePC or a Store-Release, created by having a Store-Release followed by a Load-AcquirePC instruction.
- The reading of a value written by a Store-Release by a Load-AcquirePC instruction by the same observer does not make the write of the Store-Release globally observed.

This difference in memory ordering is not described in the pseudocode.  
For information about memory accesses, see *Load/Store addressing modes*.

## Unscaled offset (FEAT\_LRCPC2)



LDAPURSW <Xt>, [<Xn|SP>{, #<sim>}]

bits(64) offset = SignExtend(imm9, 64);

## Assembler Symbols

- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(32) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = Mem[address, 4, AccType_ORDERED];
X[t] = SignExtend(data, 64);
```

## Operational information

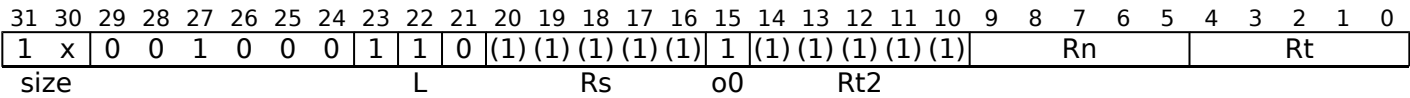
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.



# LDAR

Load-Acquire Register derives an address from a base register value, loads a 32-bit word or 64-bit doubleword from memory, and writes it to a register. The instruction also has memory ordering semantics as described in *Load-Acquire, Store-Release*. For information about memory accesses, see *Load/Store addressing modes*.

For this instruction, if the destination is WZR/XZR, it is impossible for software to observe the presence of the acquire semantic other than its effect on the arrival at endpoints.



## 32-bit (size == 10)

```
LDAR <Wt>, [<Xn|SP>{,#0}]
```

## 64-bit (size == 11)

```
LDAR <Xt>, [<Xn|SP>{,#0}]
```

```
integer n = UInt(Rn);
integer t = UInt(Rt);

integer elsize = 8 << UInt(size);
integer regsize = if elsize == 64 then 64 else 32;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(elsize) data;
constant integer dbytes = elsize DIV 8;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = Mem[address, dbytes, AccType_ORDERED];
X[t] = ZeroExtend(data, regsize);
```

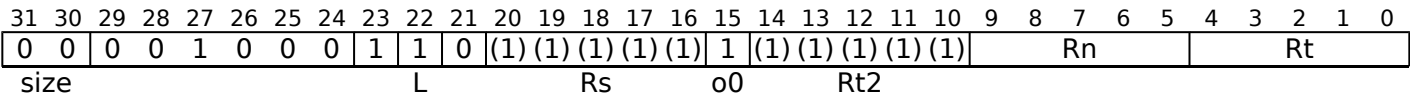
## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

# LDARB

Load-Acquire Register Byte derives an address from a base register value, loads a byte from memory, zero-extends it and writes it to a register. The instruction also has memory ordering semantics as described in *Load-Acquire, Store-Release*. For information about memory accesses, see *Load/Store addressing modes*.

For this instruction, if the destination is WZR/XZR, it is impossible for software to observe the presence of the acquire semantic other than its effect on the arrival at endpoints.



```
LDARB <Wt>, [<Xn|SP>{, #0}]

integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(8) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = Mem[address, 1, AccType_ORDERED];
X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

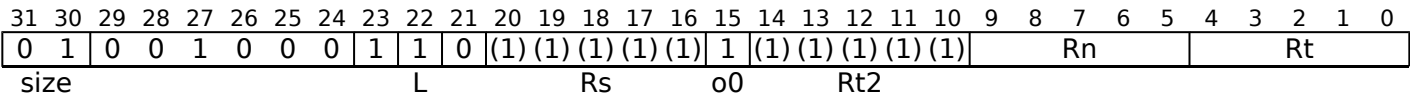
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



LDARH

Load-Acquire Register Halfword derives an address from a base register value, loads a halfword from memory, zero-extends it, and writes it to a register. The instruction also has memory ordering semantics as described in *Load-Acquire, Store-Release*. For information about memory accesses, see *Load/Store addressing modes*.  
For this instruction, if the destination is WZR/XZR, it is impossible for software to observe the presence of the acquire semantic other than its effect on the arrival at endpoints.



```
LDARH <Wt>, [<Xn|SP>{, #0}]

integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Operation

```
bits(64) address;
bits(16) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = Mem[address, 2, AccType_ORDERED];
X[t] = ZeroExtend(data, 32);
```

Operational information

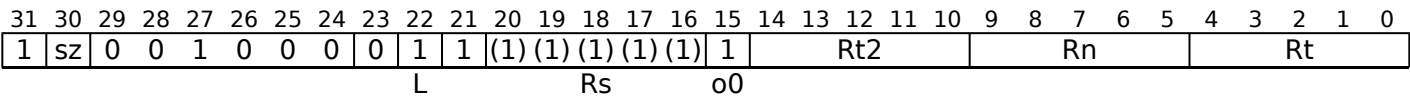
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDAXP

Load-Acquire Exclusive Pair of Registers derives an address from a base register value, loads two 32-bit words or two 64-bit doublewords from memory, and writes them to two registers. For information on single-copy atomicity and alignment requirements, see [Requirements for single-copy atomicity](#) and [Alignment of data accesses](#). The PE marks the physical address being accessed as an exclusive access. This exclusive access mark is checked by Store Exclusive instructions. See [Synchronization and semaphores](#). The instruction also has memory ordering semantics, as described in [Load-Acquire, Store-Release](#). For information about memory accesses, see [Load/Store addressing modes](#).



## 32-bit (sz == 0)

LDAXP <Wt1>, <Wt2>, [<Xn|SP>{, #0}]

## 64-bit (sz == 1)

LDAXP <Xt1>, <Xt2>, [<Xn|SP>{, #0}]

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer t2 = UInt(Rt2);

integer elsize = 32 << UInt(sz);
integer datasize = elsize * 2;
boolean tag_checked = n != 31;

boolean rt_unknown = FALSE;
if t == t2 then
    Constraint c = ConstrainUnpredictable(Unpredictable_LDPOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rt_unknown = TRUE;    // result is UNKNOWN
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [LDAXP](#).

## Assembler Symbols

- <Wt1> Is the 32-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
- <Wt2> Is the 32-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
- <Xt1> Is the 64-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt2> Is the 64-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(datasize) data;
constant integer dbytes = datasize DIV 8;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

// Tell the Exclusives monitors to record a sequence of one or more atomic
// memory reads from virtual address range [address, address+dbytes-1].
// The Exclusives monitor will only be set if all the reads are from the
// same dbytes-aligned physical address, to allow for the possibility of
// an atomicity break if the translation is changed between reads.
AArch64.SetExclusiveMonitors(address, dbytes);

if rt_unknown then
    // ConstrainedUNPREDICTABLE case
    X[t] = bits(datasize) UNKNOWN;    // In this case t = t2
elsif elsize == 32 then
    // 32-bit load exclusive pair (atomic)
    data = Mem[address, dbytes, AccType_ORDEREDATOMIC];
    if BigEndian(AccType_ORDEREDATOMIC) then
        X[t] = data<datasize-1:elsize>;
        X[t2] = data<elsize-1:0>;
    else
        X[t] = data<elsize-1:0>;
        X[t2] = data<datasize-1:elsize>;
else // elsize == 64
    // 64-bit load exclusive pair (not atomic),
    // but must be 128-bit aligned
    if address != Align(address, dbytes) then
        AArch64.Abort(address, AlignmentFault(AccType_ORDEREDATOMIC, FALSE, FALSE));
    X[t] = Mem[address, 8, AccType_ORDEREDATOMIC];
    X[t2] = Mem[address+8, 8, AccType_ORDEREDATOMIC];
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LDAXR

Load-Acquire Exclusive Register derives an address from a base register value, loads a 32-bit word or 64-bit doubleword from memory, and writes it to a register. The memory access is atomic. The PE marks the physical address being accessed as an exclusive access. This exclusive access mark is checked by Store Exclusive instructions. See [Synchronization and semaphores](#). The instruction also has memory ordering semantics as described in [Load-Acquire, Store-Release](#). For information about memory accesses see [Load/Store addressing modes](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	0	0	1	0	0	0	0	1	0	(1)	(1)	(1)	(1)	(1)	1	(1)	(1)	(1)	(1)	(1)	Rn					Rt				
size								L		Rs					o0		Rt2														

### 32-bit (size == 10)

```
LDAXR <Wt>, [<Xn|SP>{, #0}]
```

### 64-bit (size == 11)

```
LDAXR <Xt>, [<Xn|SP>{, #0}]
```

```
integer n = UInt(Rn);
integer t = UInt(Rt);

integer elsize = 8 << UInt(size);
integer regsize = if elsize == 64 then 64 else 32;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(elsize) data;
constant integer dbytes = elsize DIV 8;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

// Tell the Exclusives monitors to record a sequence of one or more atomic
// memory reads from virtual address range [address, address+dbytes-1].
// The Exclusives monitor will only be set if all the reads are from the
// same dbytes-aligned physical address, to allow for the possibility of
// an atomicity break if the translation is changed between reads.
AArch64.SetExclusiveMonitors(address, dbytes);

data = Mem[address, dbytes, AccType_ORDEREDATOMIC];
X[t] = ZeroExtend(data, regsize);
```

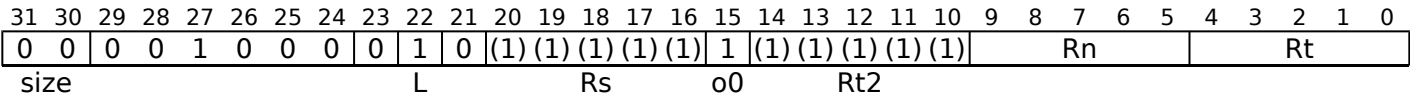
## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.



# LDAXRB

Load-Acquire Exclusive Register Byte derives an address from a base register value, loads a byte from memory, zero-extends it and writes it to a register. The PE marks the physical address being accessed as an exclusive access. This exclusive access mark is checked by Store Exclusive instructions. See [Synchronization and semaphores](#). The instruction also has memory ordering semantics as described in [Load-Acquire, Store-Release](#). For information about memory accesses see [Load/Store addressing modes](#).



```
LDAXRB <Wt>, [<Xn|SP>{, #0}]

integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(8) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

// Tell the Exclusives monitors to record a sequence of one or more atomic
// memory reads from virtual address range [address, address+dbytes-1].
// The Exclusives monitor will only be set if all the reads are from the
// same dbytes-aligned physical address, to allow for the possibility of
// an atomicity break if the translation is changed between reads.
AArch64.SetExclusiveMonitors(address, 1);

data = Mem[address, 1, AccType_ORDEREDATOMIC];
X[t] = ZeroExtend(data, 32);
```

## Operational information

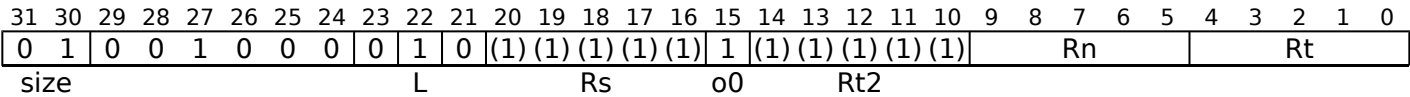
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDAXRH

Load-Acquire Exclusive Register Halfword derives an address from a base register value, loads a halfword from memory, zero-extends it and writes it to a register. The memory access is atomic. The PE marks the physical address being accessed as an exclusive access. This exclusive access mark is checked by Store Exclusive instructions. See [Synchronization and semaphores](#). The instruction also has memory ordering semantics as described in [Load-Acquire, Store-Release](#). For information about memory accesses see [Load/Store addressing modes](#).



LDAXRH <Wt>, [<Xn|SP>{, #0}]

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(16) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

// Tell the Exclusives monitors to record a sequence of one or more atomic
// memory reads from virtual address range [address, address+dbytes-1].
// The Exclusives monitor will only be set if all the reads are from the
// same dbytes-aligned physical address, to allow for the possibility of
// an atomicity break if the translation is changed between reads.
AArch64.SetExclusiveMonitors(address, 2);

data = Mem[address, 2, AccType_ORDEREDATOMIC];
X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41  
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDCLR, LDCLRA, LDCLRAL, LDCLRL

Atomic bit clear on word or doubleword in memory atomically loads a 32-bit word or 64-bit doubleword from memory, performs a bitwise AND with the complement of the value held in a register on it, and stores the result back to memory. The value initially loaded from memory is returned in the destination register.

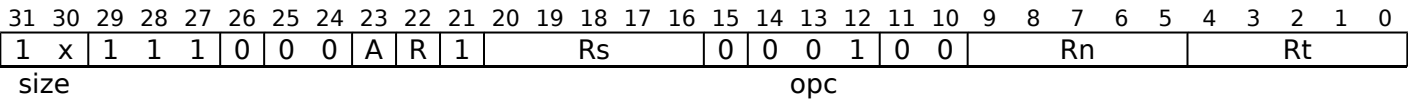
- If the destination register is not one of WZR or XZR, LDCLRA and LDCLRAL load from memory with acquire semantics.
- LDCLRL and LDCLRAL store to memory with release semantics.
- LDCLR has neither acquire nor release semantics.

For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This instruction is used by the alias [STCLR, STCLRL](#).

## Integer (FEAT\_LSE)





**32-bit LDCLR (size == 10 && A == 0 && R == 0)**

LDCLR <Ws>, <Wt>, [<Xn|SP>]

**32-bit LDCLRA (size == 10 && A == 1 && R == 0)**

LDCLRA <Ws>, <Wt>, [<Xn|SP>]

**32-bit LDCLRAL (size == 10 && A == 1 && R == 1)**

LDCLRAL <Ws>, <Wt>, [<Xn|SP>]

**32-bit LDCLRL (size == 10 && A == 0 && R == 1)**

LDCLRL <Ws>, <Wt>, [<Xn|SP>]

**64-bit LDCLR (size == 11 && A == 0 && R == 0)**

LDCLR <Xs>, <Xt>, [<Xn|SP>]

**64-bit LDCLRA (size == 11 && A == 1 && R == 0)**

LDCLRA <Xs>, <Xt>, [<Xn|SP>]

**64-bit LDCLRAL (size == 11 && A == 1 && R == 1)**

LDCLRAL <Xs>, <Xt>, [<Xn|SP>]

**64-bit LDCLRL (size == 11 && A == 0 && R == 1)**

LDCLRL <Xs>, <Xt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

integer datasize = 8 << UInt(size);
integer regsize = if datasize == 64 then 64 else 32;
AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

**Assembler Symbols**

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xs> Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xt> Is the 64-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

**Alias Conditions**

Alias	Is preferred when
<a href="#">STCLR</a> , <a href="#">STCLRL</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(datasize) value;
bits(datasize) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_BIC, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, regsize);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDCLRB, LDCLRAB, LDCLRALB, LDCLRLB

Atomic bit clear on byte in memory atomically loads an 8-bit byte from memory, performs a bitwise AND with the complement of the value held in a register on it, and stores the result back to memory. The value initially loaded from memory is returned in the destination register.

- If the destination register is not WZR, LDCLRAB and LDCLRALB load from memory with acquire semantics.
- LDCLRLB and LDCLRALB store to memory with release semantics.
- LDCLRB has neither acquire nor release semantics.

For more information about memory ordering semantics see [Load-Acquire, Store-Release](#).

For information about memory accesses see [Load/Store addressing modes](#).

This instruction is used by the alias [STCLRB, STCLRLB](#).

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	A	R	1	Rs					0	0	0	1	0	0	Rn					Rt				
size											opc																				

### LDCLRAB (A == 1 && R == 0)

LDCLRAB <Ws>, <Wt>, [<Xn|SP>]

### LDCLRALB (A == 1 && R == 1)

LDCLRALB <Ws>, <Wt>, [<Xn|SP>]

### LDCLRB (A == 0 && R == 0)

LDCLRB <Ws>, <Wt>, [<Xn|SP>]

### LDCLRLB (A == 0 && R == 1)

LDCLRLB <Ws>, <Wt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">STCLRB, STCLRLB</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(8) value;
bits(8) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_BIC, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDCLRH, LDCLRAH, LDCLRALH, LDCLRLH

Atomic bit clear on halfword in memory atomically loads a 16-bit halfword from memory, performs a bitwise AND with the complement of the value held in a register on it, and stores the result back to memory. The value initially loaded from memory is returned in the destination register.

- If the destination register is not WZR, LDCLRAH and LDCLRALH load from memory with acquire semantics.
- LDCLRLH and LDCLRALH store to memory with release semantics.
- LDCLRH has neither acquire nor release semantics.

For more information about memory ordering semantics see [Load-Acquire, Store-Release](#).

For information about memory accesses see [Load/Store addressing modes](#).

This instruction is used by the alias [STCLRH, STCLRLH](#).

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	A	R	1	Rs					0	0	0	1	0	0	Rn					Rt				
size											opc																				

### LDCLRAH (A == 1 && R == 0)

LDCLRAH <Ws>, <Wt>, [<Xn|SP>]

### LDCLRALH (A == 1 && R == 1)

LDCLRALH <Ws>, <Wt>, [<Xn|SP>]

### LDCLRH (A == 0 && R == 0)

LDCLRH <Ws>, <Wt>, [<Xn|SP>]

### LDCLRLH (A == 0 && R == 1)

LDCLRLH <Ws>, <Wt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">STCLRH, STCLRLH</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(16) value;
bits(16) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_BIC, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDEOR, LDEORA, LDEORAL, LDEORL

Atomic exclusive OR on word or doubleword in memory atomically loads a 32-bit word or 64-bit doubleword from memory, performs an exclusive OR with the value held in a register on it, and stores the result back to memory. The value initially loaded from memory is returned in the destination register.

- If the destination register is not one of WZR or XZR, LDEORA and LDEORAL load from memory with acquire semantics.
- LDEORL and LDEORAL store to memory with release semantics.
- LDEOR has neither acquire nor release semantics.

For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This instruction is used by the alias *STEOR, STEORL*.

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	0	A	R	1	Rs				0	0	1	0	0	0	Rn				Rt						
size											opc																				

**32-bit LDEOR (size == 10 && A == 0 && R == 0)**

```
LDEOR <Ws>, <Wt>, [<Xn|SP>]
```

**32-bit LDEORA (size == 10 && A == 1 && R == 0)**

```
LDEORA <Ws>, <Wt>, [<Xn|SP>]
```

**32-bit LDEORAL (size == 10 && A == 1 && R == 1)**

```
LDEORAL <Ws>, <Wt>, [<Xn|SP>]
```

**32-bit LDEORL (size == 10 && A == 0 && R == 1)**

```
LDEORL <Ws>, <Wt>, [<Xn|SP>]
```

**64-bit LDEOR (size == 11 && A == 0 && R == 0)**

```
LDEOR <Xs>, <Xt>, [<Xn|SP>]
```

**64-bit LDEORA (size == 11 && A == 1 && R == 0)**

```
LDEORA <Xs>, <Xt>, [<Xn|SP>]
```

**64-bit LDEORAL (size == 11 && A == 1 && R == 1)**

```
LDEORAL <Xs>, <Xt>, [<Xn|SP>]
```

**64-bit LDEORL (size == 11 && A == 0 && R == 1)**

```
LDEORL <Xs>, <Xt>, [<Xn|SP>]
```

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

integer datasize = 8 << UInt(size);
integer regsize = if datasize == 64 then 64 else 32;
AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

**Assembler Symbols**

<Ws>	Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Wt>	Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
<Xs>	Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xt>	Is the 64-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

**Alias Conditions**

Alias	Is preferred when
<a href="#">STEOR</a> , <a href="#">STEORL</a>	A == '0' && Rt == '11111'



## Operation

```
bits(64) address;
bits(datasize) value;
bits(datasize) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_EOR, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, regsize);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDEORB, LDEORAB, LDEORALB, LDEORLB

Atomic exclusive OR on byte in memory atomically loads an 8-bit byte from memory, performs an exclusive OR with the value held in a register on it, and stores the result back to memory. The value initially loaded from memory is returned in the destination register.

- If the destination register is not WZR, LDEORAB and LDEORALB load from memory with acquire semantics.
- LDEORLB and LDEORALB store to memory with release semantics.
- LDEORB has neither acquire nor release semantics.

For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This instruction is used by the alias [STEORB, STEORLB](#).

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	A	R	1	Rs					0	0	1	0	0	0	Rn					Rt				
size											opc																				

### LDEORAB (A == 1 && R == 0)

LDEORAB <Ws>, <Wt>, [<Xn|SP>]

### LDEORALB (A == 1 && R == 1)

LDEORALB <Ws>, <Wt>, [<Xn|SP>]

### LDEORB (A == 0 && R == 0)

LDEORB <Ws>, <Wt>, [<Xn|SP>]

### LDEORLB (A == 0 && R == 1)

LDEORLB <Ws>, <Wt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">STEORB, STEORLB</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(8) value;
bits(8) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_EOR, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDEORH, LDEORAH, LDEORALH, LDEORLH

Atomic exclusive OR on halfword in memory atomically loads a 16-bit halfword from memory, performs an exclusive OR with the value held in a register on it, and stores the result back to memory. The value initially loaded from memory is returned in the destination register.

- If the destination register is not WZR, LDEORAH and LDEORALH load from memory with acquire semantics.
- LDEORLH and LDEORALH store to memory with release semantics.
- LDEORH has neither acquire nor release semantics.

For more information about memory ordering semantics see [Load-Acquire, Store-Release](#).

For information about memory accesses see [Load/Store addressing modes](#).

This instruction is used by the alias [STEORH, STEORLH](#).

## Integer

(FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	A	R	1	Rs					0	0	1	0	0	0	Rn					Rt				
size											opc																				

### LDEORAH (A == 1 && R == 0)

LDEORAH <Ws>, <Wt>, [<Xn|SP>]

### LDEORALH (A == 1 && R == 1)

LDEORALH <Ws>, <Wt>, [<Xn|SP>]

### LDEORH (A == 0 && R == 0)

LDEORH <Ws>, <Wt>, [<Xn|SP>]

### LDEORLH (A == 0 && R == 1)

LDEORLH <Ws>, <Wt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">STEORH, STEORLH</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(16) value;
bits(16) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_EOR, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

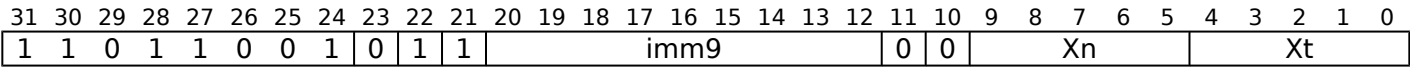
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

LDG

Load Allocation Tag loads an Allocation Tag from a memory address, generates a Logical Address Tag from the Allocation Tag and merges it into the destination register. The address used for the load is calculated from the base register and an immediate signed offset scaled by the Tag granule.

Integer  
(FEAT\_MTE)



LDG <Xt>, [<Xn|SP>{, #<simm>}]

```
if !HaveMTEExt() then UNDEFINED;
integer t = UInt(Xt);
integer n = UInt(Xn);
bits(64) offset = LSL(SignExtend(imm9, 64), LOG2_TAG_GRANULE);
```

Assembler Symbols

- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Xt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Xn" field.
- <simm> Is the optional signed immediate offset, a multiple of 16 in the range -4096 to 4080, defaulting to 0 and encoded in the "imm9" field.

Operation

```
bits(64) address;
bits(4) tag;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;
address = Align(address, TAG_GRANULE);

tag = AArch64.MemTag[address, AccType_NORMAL];
X[t] = AArch64.AddressWithAllocationTag(X[t], AccType_NORMAL, tag);
```

## LDGM

Load Tag Multiple reads a naturally aligned block of N Allocation Tags, where the size of N is identified in GMID\_EL1.BS, and writes the Allocation Tag read from address A to the destination register at  $4*A<7:4>+3:4*A<7:4>$ . Bits of the destination register not written with an Allocation Tag are set to 0.

This instruction is UNDEFINED at EL0.

This instruction generates an Unchecked access.

If [ID\\_AA64PFR1\\_EL1.MTE](#) != 0b0010, this instruction is UNDEFINED.

### Integer (FEAT\_MTE2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	Xn					Xt				

**LDGM** <Xt>, [<Xn|SP>]

```
if !HaveMTE2Ext() then UNDEFINED;
integer t = UInt(Xt);
integer n = UInt(Xn);
```

### Assembler Symbols

- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Xt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Xn" field.

### Operation

```
if PSTATE.EL == EL0 then
    UNDEFINED;

bits(64) data = Zeros(64);
bits(64) address;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

integer size = 4 * (2 ^ (UInt(GMID_EL1.BS)));
address = Align(address, size);
integer count = size >> LOG2_TAG_GRANULE;
integer index = UInt(address<LOG2_TAG_GRANULE+3:LOG2_TAG_GRANULE>);

for i = 0 to count-1
    bits(4) tag = AArch64.MemTag[address, AccType_NORMAL];
    data<(index*4)+3:index*4> = tag;
    address = address + TAG_GRANULE;
    index = index + 1;

X[t] = data;
```

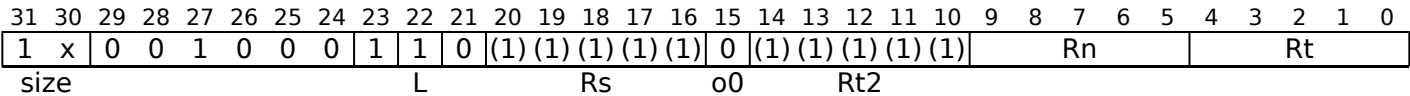
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDLAR

Load LOAcquire Register loads a 32-bit word or 64-bit doubleword from memory, and writes it to a register. The instruction also has memory ordering semantics as described in [Load LOAcquire, Store LORelease](#). For information about memory accesses, see [Load/Store addressing modes](#).  
For this instruction, if the destination is WZR/XZR, it is impossible for software to observe the presence of the acquire semantic other than its effect on the arrival at endpoints.

## No offset (FEAT\_LOR)



### 32-bit (size == 10)

```
LDLAR <Wt>, [<Xn|SP>{, #0}]
```

### 64-bit (size == 11)

```
LDLAR <Xt>, [<Xn|SP>{, #0}]
```

```
integer n = UInt(Rn);
integer t = UInt(Rt);

integer elsize = 8 << UInt(size);
integer regsize = if elsize == 64 then 64 else 32;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(elsize) data;
constant integer dbytes = elsize DIV 8;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = Mem[address, dbytes, AccType_LIMITEDORDERED];
X[t] = ZeroExtend(data, regsize);
```

## Operational information

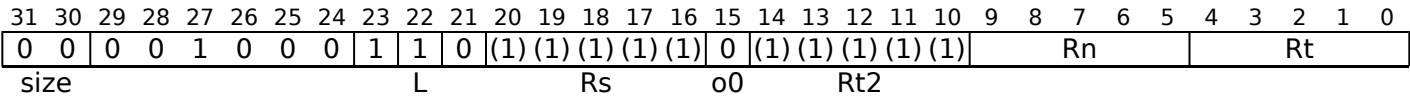
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.



LDLARB

Load LOAcquire Register Byte loads a byte from memory, zero-extends it and writes it to a register. The instruction also has memory ordering semantics as described in *Load LOAcquire, Store LORelease*. For information about memory accesses, see *Load/Store addressing modes*.  
For this instruction, if the destination is WZR/XZR, it is impossible for software to observe the presence of the acquire semantic other than its effect on the arrival at endpoints.

No offset  
(FEAT\_LOR)



```
LDLARB <Wt>, [<Xn|SP>{, #0}]

integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Operation

```
bits(64) address;
bits(8) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = Mem[address, 1, AccType_LIMITEDORDERED];
X[t] = ZeroExtend(data, 32);
```

Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

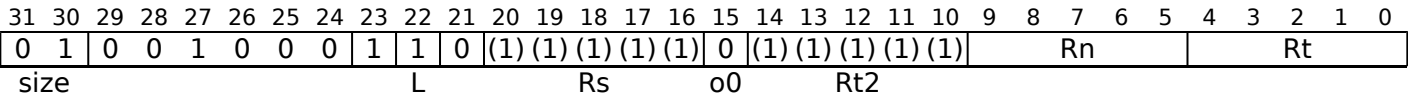
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

LDLARH

Load LOAcquire Register Halfword loads a halfword from memory, zero-extends it, and writes it to a register. The instruction also has memory ordering semantics as described in [Load LOAcquire, Store LORelease](#). For information about memory accesses, see [Load/Store addressing modes](#).  
For this instruction, if the destination is WZR/XZR, it is impossible for software to observe the presence of the acquire semantic other than its effect on the arrival at endpoints.

No offset  
(FEAT\_LOR)



```
LDLARH <Wt>, [<Xn|SP>{, #0}]

integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Operation

```
bits(64) address;
bits(16) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = Mem[address, 2, AccType_LIMITEDORDERED];
X[t] = ZeroExtend(data, 32);
```

Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LDNP

Load Pair of Registers, with non-temporal hint, calculates an address from a base register value and an immediate offset, loads two 32-bit words or two 64-bit doublewords from memory, and writes them to two registers.

For information about memory accesses, see [Load/Store addressing modes](#). For information about Non-temporal pair instructions, see [Load/Store Non-temporal pair](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
x	0	1	0	1	0	0	0	0	1	imm7							Rt2				Rn				Rt						
opc										L																					

### 32-bit (opc == 00)

```
LDNP <Wt1>, <Wt2>, [<Xn|SP>{, #<imm>}]
```

### 64-bit (opc == 10)

```
LDNP <Xt1>, <Xt2>, [<Xn|SP>{, #<imm>}]
```

```
// Empty.
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [LDNP](#).

## Assembler Symbols

- <Wt1> Is the 32-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
- <Wt2> Is the 32-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
- <Xt1> Is the 64-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt2> Is the 64-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> For the 32-bit variant: is the optional signed immediate byte offset, a multiple of 4 in the range -256 to 252, defaulting to 0 and encoded in the "imm7" field as <imm>/4.  
For the 64-bit variant: is the optional signed immediate byte offset, a multiple of 8 in the range -512 to 504, defaulting to 0 and encoded in the "imm7" field as <imm>/8.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer t2 = UInt(Rt2);
if opc<0> == '1' then UNDEFINED;
integer scale = 2 + UInt(opc<1>);
integer datasize = 8 << scale;
bits(64) offset = LSL(SignExtend(imm7, 64), scale);
boolean tag_checked = n != 31;

boolean rt_unknown = FALSE;

if t == t2 then
    Constraint c = ConstrainUnpredictable(Unpredictable_LDPOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rt_unknown = TRUE;    // result is UNKNOWN
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();
```

## Operation

```
bits(64) address;
bits(datasize) data1;
bits(datasize) data2;
constant integer dbytes = datasize DIV 8;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

if HaveLSE2Ext() then
    bits(2*datasize) full_data;
    full_data = Mem[address, 2*dbytes, AccType_NORMAL, TRUE];
    if BigEndian(AccType_STREAM) then
        data2 = full_data<(datasize-1):0>;
        data1 = full_data<(2*datasize-1):datasize>;
    else
        data1 = full_data<(datasize-1):0>;
        data2 = full_data<(2*datasize-1):datasize>;
else
    data1 = Mem[address, dbytes, AccType_STREAM];
    data2 = Mem[address+dbytes, dbytes, AccType_STREAM];
if rt_unknown then
    data1 = bits(datasize) UNKNOWN;
    data2 = bits(datasize) UNKNOWN;
X[t] = data1;
X[t2] = data2;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LDP

Load Pair of Registers calculates an address from a base register value and an immediate offset, loads two 32-bit words or two 64-bit doublewords from memory, and writes them to two registers. For information about memory accesses, see [Load/Store addressing modes](#).

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Signed offset](#)

### Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0					
x	0	1	0	1	0	0	0	1	1	imm7							Rt2				Rn				Rt											
opc										L																										

#### 32-bit (opc == 00)

LDP <Wt1>, <Wt2>, [<Xn|SP>], #<imm>

#### 64-bit (opc == 10)

LDP <Xt1>, <Xt2>, [<Xn|SP>], #<imm>

```
boolean wback = TRUE;  
boolean postindex = TRUE;
```

### Pre-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0					
x	0	1	0	1	0	0	1	1	1	imm7							Rt2				Rn				Rt											
opc										L																										

#### 32-bit (opc == 00)

LDP <Wt1>, <Wt2>, [<Xn|SP>, #<imm>]!

#### 64-bit (opc == 10)

LDP <Xt1>, <Xt2>, [<Xn|SP>, #<imm>]!

```
boolean wback = TRUE;  
boolean postindex = FALSE;
```

### Signed offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0					
x	0	1	0	1	0	0	1	0	1	imm7							Rt2				Rn				Rt											
opc										L																										

#### 32-bit (opc == 00)

LDP <Wt1>, <Wt2>, [<Xn|SP>{, #<imm>}]

#### 64-bit (opc == 10)

LDP <Xt1>, <Xt2>, [<Xn|SP>{, #<imm>}]

```
boolean wback = FALSE;  
boolean postindex = FALSE;
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [LDP](#).

## Assembler Symbols

<Wt1>	Is the 32-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
<Wt2>	Is the 32-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
<Xt1>	Is the 64-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
<Xt2>	Is the 64-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<imm>	<p>For the 32-bit post-index and 32-bit pre-index variant: is the signed immediate byte offset, a multiple of 4 in the range -256 to 252, encoded in the "imm7" field as &lt;imm&gt;/4.</p> <p>For the 32-bit signed offset variant: is the optional signed immediate byte offset, a multiple of 4 in the range -256 to 252, defaulting to 0 and encoded in the "imm7" field as &lt;imm&gt;/4.</p> <p>For the 64-bit post-index and 64-bit pre-index variant: is the signed immediate byte offset, a multiple of 8 in the range -512 to 504, encoded in the "imm7" field as &lt;imm&gt;/8.</p> <p>For the 64-bit signed offset variant: is the optional signed immediate byte offset, a multiple of 8 in the range -512 to 504, defaulting to 0 and encoded in the "imm7" field as &lt;imm&gt;/8.</p>

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer t2 = UInt(Rt2);
if L:opc<0> == '01' || opc == '11' then UNDEFINED;
boolean signed = (opc<0> != '0');
integer scale = 2 + UInt(opc<1>);
integer datasize = 8 << scale;
bits(64) offset = LSL(SignExtend(imm7, 64), scale);
boolean tag_checked = wback || n != 31;

boolean rt_unknown = FALSE;
boolean wb_unknown = FALSE;

if wback && (t == n || t2 == n) && n != 31 then
    Constraint c = ConstrainUnpredictable(Unpredictable_WBOVERLAPLD);
    assert c IN {Constraint_WBSUPPRESS, Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_WBSUPPRESS wback = FALSE;    // writeback is suppressed
        when Constraint_UNKNOWN    wb_unknown = TRUE;    // writeback is UNKNOWN
        when Constraint_UNDEF      UNDEFINED;
        when Constraint_NOP        EndOfInstruction();

if t == t2 then
    Constraint c = ConstrainUnpredictable(Unpredictable_LDPOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rt_unknown = TRUE;    // result is UNKNOWN
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();
```

## Operation

```
bits(64) address;
bits(datasize) data1;
bits(datasize) data2;
constant integer dbytes = datasize DIV 8;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

if HaveLSE2Ext() && !signed then
    bits(2*datasize) full_data;
    full_data = Mem[address, 2*dbytes, AccType_NORMAL, TRUE];
    if BigEndian(AccType_NORMAL) then
        data2 = full_data<(datasize-1):0>;
        data1 = full_data<(2*datasize-1):datasize>;
    else
        data1 = full_data<(datasize-1):0>;
        data2 = full_data<(2*datasize-1):datasize>;
else
    data1 = Mem[address, dbytes, AccType_NORMAL];
    data2 = Mem[address+dbytes, dbytes, AccType_NORMAL];
if rt_unknown then
    data1 = bits(datasize) UNKNOWN;
    data2 = bits(datasize) UNKNOWN;
if signed then
    X[t] = SignExtend(data1, 64);
    X[t2] = SignExtend(data2, 64);
else
    X[t] = data1;
    X[t2] = data2;

if wback then
    if wb_unknown then
        address = bits(64) UNKNOWN;
    elsif postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDPSW

Load Pair of Registers Signed Word calculates an address from a base register value and an immediate offset, loads two 32-bit words from memory, sign-extends them, and writes them to two registers. For information about memory accesses, see [Load/Store addressing modes](#).

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Signed offset](#)

## Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	0	1	1	imm7							Rt2				Rn				Rt						
opc										L																					

LDPSW <Xt1>, <Xt2>, [<Xn|SP>], #<imm>

```
boolean wback = TRUE;
boolean postindex = TRUE;
```

## Pre-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	1	1	imm7							Rt2				Rn				Rt						
opc										L																					

LDPSW <Xt1>, <Xt2>, [<Xn|SP>], #<imm>!

```
boolean wback = TRUE;
boolean postindex = FALSE;
```

## Signed offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	0	1	imm7							Rt2				Rn				Rt						
opc										L																					

LDPSW <Xt1>, <Xt2>, [<Xn|SP>{, #<imm>}]

```
boolean wback = FALSE;
boolean postindex = FALSE;
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [LDPSW](#).

## Assembler Symbols

- <Xt1> Is the 64-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt2> Is the 64-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> For the post-index and pre-index variant: is the signed immediate byte offset, a multiple of 4 in the range -256 to 252, encoded in the "imm7" field as <imm>/4.  
For the signed offset variant: is the optional signed immediate byte offset, a multiple of 4 in the range -256 to 252, defaulting to 0 and encoded in the "imm7" field as <imm>/4.



## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer t2 = UInt(Rt2);
bits(64) offset = LSL(SignExtend(imm7, 64), 2);
boolean tag_checked = wback || n != 31;

boolean rt_unknown = FALSE;
boolean wb_unknown = FALSE;

if wback && (t == n || t2 == n) && n != 31 then
  Constraint c = ConstrainUnpredictable(Unpredictable_WBOVERLAPLD);
  assert c IN {Constraint_WBSUPPRESS, Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
  case c of
    when Constraint_WBSUPPRESS wback = FALSE;    // writeback is suppressed
    when Constraint_UNKNOWN    wb_unknown = TRUE; // writeback is UNKNOWN
    when Constraint_UNDEF      UNDEFINED;
    when Constraint_NOP        EndOfInstruction();

if t == t2 then
  Constraint c = ConstrainUnpredictable(Unpredictable_LDPOVERLAP);
  assert c IN {Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
  case c of
    when Constraint_UNKNOWN rt_unknown = TRUE;    // result is UNKNOWN
    when Constraint_UNDEF   UNDEFINED;
    when Constraint_NOP     EndOfInstruction();
```

## Operation

```
bits(64) address;
bits(32) data1;
bits(32) data2;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

if HaveLSE2Ext() && FALSE then
    bits(64) full_data;
    full_data = Mem[address, 8, AccType_NORMAL, TRUE];
    if BigEndian(AccType_NORMAL) then
        data2 = full_data<31:0>;
        data1 = full_data<63:32>;
    else
        data1 = full_data<31:0>;
        data2 = full_data<63:32>;
else
    data1 = Mem[address, 4, AccType_NORMAL];
    data2 = Mem[address+4, 4, AccType_NORMAL];
if rt_unknown then
    data1 = bits(32) UNKNOWN;
    data2 = bits(32) UNKNOWN;
X[t] = SignExtend(data1, 64);
X[t2] = SignExtend(data2, 64);
if wback then
    if wb_unknown then
        address = bits(64) UNKNOWN;
    elsif postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDR (immediate)

Load Register (immediate) loads a word or doubleword from memory and writes it to a register. The address that is used for the load is calculated from a base register and an immediate offset. For information about memory accesses, see [Load/Store addressing modes](#). The Unsigned offset variant scales the immediate offset value by the size of the value accessed before adding it to the base register value.

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Unsigned offset](#)

## Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	0	0	1	0	imm9									0	1	Rn				Rt					
size										opc																					

### 32-bit (size == 10)

```
LDR <Wt>, [<Xn|SP>], #<sim>
```

### 64-bit (size == 11)

```
LDR <Xt>, [<Xn|SP>], #<sim>
```

```
boolean wback = TRUE;
boolean postindex = TRUE;
integer scale = UInt(size);
bits(64) offset = SignExtend(imm9, 64);
```

## Pre-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	0	0	1	0	imm9									1	1	Rn				Rt					
size										opc																					

### 32-bit (size == 10)

```
LDR <Wt>, [<Xn|SP>, #<sim>]!
```

### 64-bit (size == 11)

```
LDR <Xt>, [<Xn|SP>, #<sim>]!
```

```
boolean wback = TRUE;
boolean postindex = FALSE;
integer scale = UInt(size);
bits(64) offset = SignExtend(imm9, 64);
```

## Unsigned offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	1	0	1	imm12											Rn				Rt						
size										opc																					

### 32-bit (size == 10)

```
LDR <Wt>, [<Xn|SP>{, #<pimm>}]
```

### 64-bit (size == 11)

```
LDR <Xt>, [<Xn|SP>{, #<pimm>}]
```

```
boolean wback = FALSE;  
boolean postindex = FALSE;  
integer scale = UInt(size);  
bits(64) offset = LSL(ZeroExtend(imm12, 64), scale);
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [LDR \(immediate\)](#).

## Assembler Symbols

<Wt>	Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
<Xt>	Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<sim>	Is the signed immediate byte offset, in the range -256 to 255, encoded in the "imm9" field.
<pimm>	For the 32-bit variant: is the optional positive immediate byte offset, a multiple of 4 in the range 0 to 16380, defaulting to 0 and encoded in the "imm12" field as <pimm>/4. For the 64-bit variant: is the optional positive immediate byte offset, a multiple of 8 in the range 0 to 32760, defaulting to 0 and encoded in the "imm12" field as <pimm>/8.

## Shared Decode

```
integer n = UInt(Rn);  
integer t = UInt(Rt);  
integer regsize;  
  
regsize = if size == '11' then 64 else 32;  
integer datasize = 8 << scale;  
boolean tag_checked = wback || n != 31;  
  
boolean wb_unknown = FALSE;  
  
if wback && n == t && n != 31 then  
  c = ConstrainUnpredictable(Unpredictable_WBOVERLAPLD);  
  assert c IN {Constraint_WBSUPPRESS, Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};  
  case c of  
    when Constraint_WBSUPPRESS wback = FALSE;    // writeback is suppressed  
    when Constraint_UNKNOWN    wb_unknown = TRUE;  // writeback is UNKNOWN  
    when Constraint_UNDEF      UNDEFINED;  
    when Constraint_NOP        EndOfInstruction();
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(datasize) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

data = Mem[address, datasize DIV 8, AccType_NORMAL];
X[t] = ZeroExtend(data, regsize);

if wback then
    if wb_unknown then
        address = bits(64) UNKNOWN;
    elsif postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

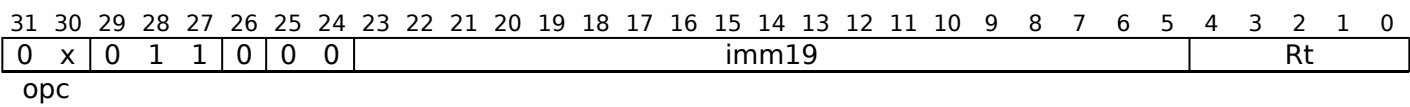
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDR (literal)

Load Register (literal) calculates an address from the PC value and an immediate offset, loads a word from memory, and writes it to a register. For information about memory accesses, see [Load/Store addressing modes](#).



## 32-bit (opc == 00)

```
LDR <Wt>, <label>
```

## 64-bit (opc == 01)

```
LDR <Xt>, <label>
```

```
integer t = UInt(Rt);
MemOp memop = MemOp_LOAD;
boolean signed = FALSE;
integer size;
bits(64) offset;

case opc of
  when '00'
    size = 4;
  when '01'
    size = 8;
  when '10'
    size = 4;
    signed = TRUE;
  when '11'
    memop = MemOp_PREFETCH;

offset = SignExtend(imm19:'00', 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <label> Is the program label from which the data is to be loaded. Its offset from the address of this instruction, in the range +/-1MB, is encoded as "imm19" times 4.

## Operation

```
bits(64) address = PC[] + offset;
bits(size*8) data;

if HaveMTE2Ext() then
  SetTagCheckedInstruction(FALSE);

case memop of
  when MemOp_LOAD
    data = Mem[address, size, AccType_NORMAL];
    if signed then
      X[t] = SignExtend(data, 64);
    else
      X[t] = data;

  when MemOp_PREFETCH
    Prefetch(address, t<4:0>);
```

## Operational information

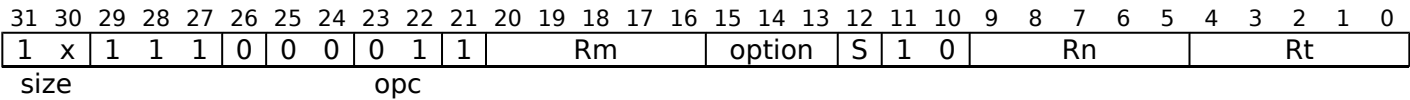
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

LDR (register)

Load Register (register) calculates an address from a base register value and an offset register value, loads a word from memory, and writes it to a register. The offset register value can optionally be shifted and extended. For information about memory accesses, see [Load/Store addressing modes](#).



32-bit (size == 10)

```
LDR <Wt>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]
```

64-bit (size == 11)

```
LDR <Xt>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]
```

```
integer scale = UInt(size);
if option<1> == '0' then UNDEFINED;    // sub-word index
ExtendType extend_type = DecodeRegExtend(option);
integer shift = if S == '1' then scale else 0;
```

Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Wm> When option<0> is set to 0, is the 32-bit name of the general-purpose index register, encoded in the "Rm" field.
- <Xm> When option<0> is set to 1, is the 64-bit name of the general-purpose index register, encoded in the "Rm" field.
- <extend> Is the index extend/shift specifier, defaulting to LSL, and which must be omitted for the LSL option when <amount> is omitted. encoded in "option":

option	<extend>
010	UXTW
011	LSL
110	SXTW
111	SCTX

<amount> For the 32-bit variant: is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in "S":

S	<amount>
0	#0
1	#2

For the 64-bit variant: is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in "S":

S	<amount>
0	#0
1	#3



## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer m = UInt(Rm);
integer regsize;

regsize = if size == '11' then 64 else 32;
integer datasize = 8 << scale;
```

## Operation

```
bits(64) offset = ExtendReg(m, extend_type, shift);
if HaveMTE2Ext() then
    SetTagCheckedInstruction(TRUE);

bits(64) address;
bits(datasize) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = Mem[address, datasize DIV 8, AccType_NORMAL];
X[t] = ZeroExtend(data, regsize);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDRAA, LDRAB

Load Register, with pointer authentication. This instruction authenticates an address from a base register using a modifier of zero and the specified key, adds an immediate offset to the authenticated address, and loads a 64-bit doubleword from memory at this resulting address into a register.

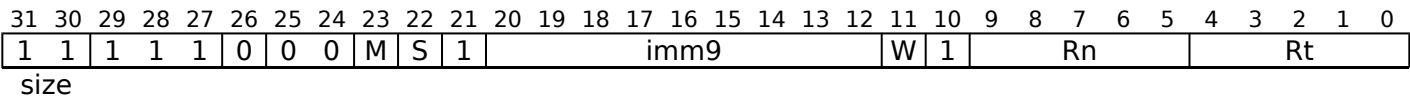
Key A is used for LDRAA, and key B is used for LDRAB.

If the authentication passes, the PE behaves the same as for an LDR instruction. If the authentication fails, a Translation fault is generated.

The authenticated address is not written back to the base register, unless the pre-indexed variant of the instruction is used. In this case, the address that is written back to the base register does not include the pointer authentication code.

For information about memory accesses, see [Load/Store addressing modes](#).

## Unscaled offset (FEAT\_PAAuth)



### Key A, offset (M == 0 && W == 0)

```
LDRAA <Xt>, [<Xn|SP>{, #<simm>}]
```

### Key A, pre-indexed (M == 0 && W == 1)

```
LDRAA <Xt>, [<Xn|SP>{, #<simm>}]!
```

### Key B, offset (M == 1 && W == 0)

```
LDRAB <Xt>, [<Xn|SP>{, #<simm>}]
```

### Key B, pre-indexed (M == 1 && W == 1)

```
LDRAB <Xt>, [<Xn|SP>{, #<simm>}]!
```

```
if !HavePACExt() then UNDEFINED;
integer t = UInt(Rt);
integer n = UInt(Rn);
boolean wback = (W == '1');
boolean use_key_a = (M == '0');
bits(10) S10 = S:imm9;
bits(64) offset = LSL(SignExtend(S10, 64), 3);
boolean tag_checked = wback || n != 31;
```

## Assembler Symbols

- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <simm> Is the optional signed immediate byte offset, a multiple of 8 in the range -4096 to 4088, defaulting to 0 and encoded in the "S:imm9" field as <simm>/8.

## Operation

```
bits(64) address;
bits(64) data;
boolean wb_unknown = FALSE;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if wback && n == t && n != 31 then
    c = ConstrainUnpredictable(Unpredictable_WBOVERLAPLD);
    assert c IN {Constraint_WBSUPPRESS, Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_WBSUPPRESS wback = FALSE;    // writeback is suppressed
        when Constraint_UNKNOWN    wb_unknown = TRUE; // writeback is UNKNOWN
        when Constraint_UNDEF      UNDEFINED;
        when Constraint_NOP        EndOfInstruction();

if n == 31 then
    address = SP[];
else
    address = X[n];

if use_key_a then
    address = AuthDA(address, X[31], TRUE);
else
    address = AuthDB(address, X[31], TRUE);

if n == 31 then
    CheckSPAlignment();

address = address + offset;
data = Mem[address, 8, AccType_NORMAL];
X[t] = data;

if wback then
    if wb_unknown then
        address = bits(64) UNKNOWN;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDRB (immediate)

Load Register Byte (immediate) loads a byte from memory, zero-extends it, and writes the result to a register. The address that is used for the load is calculated from a base register and an immediate offset. For information about memory accesses, see [Load/Store addressing modes](#).

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Unsigned offset](#)

## Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	0	1	0	imm9									0	1	Rn				Rt					
size										opc																					

LDRB <Wt>, [<Xn|SP>], #<sim>

```
boolean wback = TRUE;
boolean postindex = TRUE;
bits(64) offset = SignExtend(imm9, 64);
```

## Pre-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	0	1	0	imm9									1	1	Rn				Rt					
size										opc																					

LDRB <Wt>, [<Xn|SP>, #<sim>]!

```
boolean wback = TRUE;
boolean postindex = FALSE;
bits(64) offset = SignExtend(imm9, 64);
```

## Unsigned offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	1	0	1	imm12											Rn				Rt						
size										opc																					

LDRB <Wt>, [<Xn|SP>{, #<pimm>}]

```
boolean wback = FALSE;
boolean postindex = FALSE;
bits(64) offset = LSL(ZeroExtend(imm12, 64), 0);
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [LDRH \(immediate\)](#).

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the signed immediate byte offset, in the range -256 to 255, encoded in the "imm9" field.
- <pimm> Is the optional positive immediate byte offset, in the range 0 to 4095, defaulting to 0 and encoded in the "imm12" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = wback || n != 31;

boolean wb_unknown = FALSE;

if wback && n == t && n != 31 then
    c = ConstrainUnpredictable(Unpredictable_WBOVERLAPLD);
    assert c IN {Constraint_WBSUPPRESS, Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_WBSUPPRESS wback = FALSE;    // writeback is suppressed
        when Constraint_UNKNOWN    wb_unknown = TRUE; // writeback is UNKNOWN
        when Constraint_UNDEF      UNDEFINED;
        when Constraint_NOP        EndOfInstruction();
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(8) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

data = Mem[address, 1, AccType_NORMAL];
X[t] = ZeroExtend(data, 32);

if wback then
    if wb_unknown then
        address = bits(64) UNKNOWN;
    elsif postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LDRB (register)

Load Register Byte (register) calculates an address from a base register value and an offset register value, loads a byte from memory, zero-extends it, and writes it to a register. For information about memory accesses, see [Load/Store addressing modes](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	0	1	1	Rm				option		S	1	0	Rn				Rt							
size											opc																				

### Extended register (option != 011)

```
LDRB <Wt>, [<Xn|SP>, (<Wm>|<Xm>), <extend> {<amount>}]
```

### Shifted register (option == 011)

```
LDRB <Wt>, [<Xn|SP>, <Xm>{, LSL <amount>}]
```

```
if option<1> == '0' then UNDEFINED; // sub-word index
ExtendType extend_type = DecodeRegExtend(option);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Wm> When option<0> is set to 0, is the 32-bit name of the general-purpose index register, encoded in the "Rm" field.
- <Xm> When option<0> is set to 1, is the 64-bit name of the general-purpose index register, encoded in the "Rm" field.
- <extend> Is the index extend specifier, encoded in "option":

option	<extend>
010	UXTW
110	SXTW
111	SCTX

<amount> Is the index shift amount, it must be #0, encoded in "S" as 0 if omitted, or as 1 if present.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer m = UInt(Rm);
```

## Operation

```
bits(64) offset = ExtendReg(m, extend_type, 0);
if HaveMTE2Ext() then
    SetTagCheckedInstruction(TRUE);

bits(64) address;
bits(8) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = Mem[address, 1, AccType_NORMAL];
X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDRH (immediate)

Load Register Halfword (immediate) loads a halfword from memory, zero-extends it, and writes the result to a register. The address that is used for the load is calculated from a base register and an immediate offset. For information about memory accesses, see [Load/Store addressing modes](#).

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Unsigned offset](#)

## Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	0	1	0	imm9									0	1	Rn				Rt					
size										opc																					

LDRH <Wt>, [<Xn|SP>], #<sim>

```
boolean wback = TRUE;
boolean postindex = TRUE;
bits(64) offset = SignExtend(imm9, 64);
```

## Pre-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	0	1	0	imm9									1	1	Rn				Rt					
size										opc																					

LDRH <Wt>, [<Xn|SP>, #<sim>]!

```
boolean wback = TRUE;
boolean postindex = FALSE;
bits(64) offset = SignExtend(imm9, 64);
```

## Unsigned offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	1	0	1	imm12											Rn				Rt						
size										opc																					

LDRH <Wt>, [<Xn|SP>{, #<pimm>}]

```
boolean wback = FALSE;
boolean postindex = FALSE;
bits(64) offset = LSL(ZeroExtend(imm12, 64), 1);
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [LDRH \(immediate\)](#).

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the signed immediate byte offset, in the range -256 to 255, encoded in the "imm9" field.
- <pimm> Is the optional positive immediate byte offset, a multiple of 2 in the range 0 to 8190, defaulting to 0 and encoded in the "imm12" field as <pimm>/2.



## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = wback || n != 31;

boolean wb_unknown = FALSE;

if wback && n == t && n != 31 then
    c = ConstrainUnpredictable(Unpredictable_WBOVERLAPLD);
    assert c IN {Constraint_WBSUPPRESS, Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_WBSUPPRESS wback = FALSE;    // writeback is suppressed
        when Constraint_UNKNOWN    wb_unknown = TRUE; // writeback is UNKNOWN
        when Constraint_UNDEF      UNDEFINED;
        when Constraint_NOP        EndOfInstruction();
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(16) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

data = Mem[address, 2, AccType_NORMAL];
X[t] = ZeroExtend(data, 32);

if wback then
    if wb_unknown then
        address = bits(64) UNKNOWN;
    elsif postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

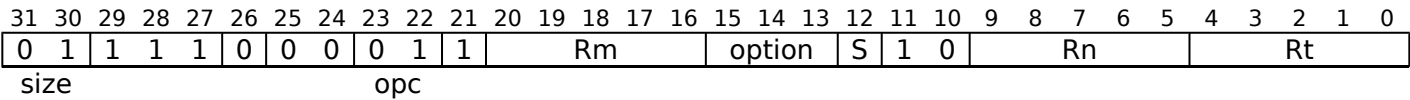
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

LDRH (register)

Load Register Halfword (register) calculates an address from a base register value and an offset register value, loads a halfword from memory, zero-extends it, and writes it to a register. For information about memory accesses, see [Load/Store addressing modes](#).



LDRH <Wt>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]

```
if option<1> == '0' then UNDEFINED;    // sub-word index
ExtendType extend_type = DecodeRegExtend(option);
integer shift = if S == '1' then 1 else 0;
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#).

Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Wm> When option<0> is set to 0, is the 32-bit name of the general-purpose index register, encoded in the "Rm" field.
- <Xm> When option<0> is set to 1, is the 64-bit name of the general-purpose index register, encoded in the "Rm" field.
- <extend> Is the index extend/shift specifier, defaulting to LSL, and which must be omitted for the LSL option when <amount> is omitted. encoded in "option":

option	<extend>
010	UXTW
011	LSL
110	SXTW
111	SCTX

- <amount> Is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in "S":

S	<amount>
0	#0
1	#1

Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer m = UInt(Rm);
```

## Operation

```
bits(64) offset = ExtendReg(m, extend_type, shift);
if HaveMTE2Ext() then
    SetTagCheckedInstruction(TRUE);

bits(64) address;
bits(16) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = Mem[address, 2, AccType_NORMAL];
X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDRSB (immediate)

Load Register Signed Byte (immediate) loads a byte from memory, sign-extends it to either 32 bits or 64 bits, and writes the result to a register. The address that is used for the load is calculated from a base register and an immediate offset. For information about memory accesses, see [Load/Store addressing modes](#).

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Unsigned offset](#)

## Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	1	x	0	imm9									0	1	Rn				Rt					
size										opc																					

### 32-bit (opc == 11)

```
LDRSB <Wt>, [<Xn|SP>], #<sim>
```

### 64-bit (opc == 10)

```
LDRSB <Xt>, [<Xn|SP>], #<sim>
```

```
boolean wback = TRUE;
boolean postindex = TRUE;
bits(64) offset = SignExtend(imm9, 64);
```

## Pre-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	1	x	0	imm9									1	1	Rn				Rt					
size										opc																					

### 32-bit (opc == 11)

```
LDRSB <Wt>, [<Xn|SP>, #<sim>]!
```

### 64-bit (opc == 10)

```
LDRSB <Xt>, [<Xn|SP>, #<sim>]!
```

```
boolean wback = TRUE;
boolean postindex = FALSE;
bits(64) offset = SignExtend(imm9, 64);
```

## Unsigned offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	1	1	x	imm12												Rn				Rt					
size										opc																					

**32-bit (opc == 11)**

```
LDRSB <Wt>, [<Xn|SP>{, #<pimm>}]
```

**64-bit (opc == 10)**

```
LDRSB <Xt>, [<Xn|SP>{, #<pimm>}]
```

```
boolean wback = FALSE;
boolean postindex = FALSE;
bits(64) offset = LSL(ZeroExtend(imm12, 64), 0);
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see *Architectural Constraints on UNPREDICTABLE behaviors*, and particularly *LDRSB (immediate)*.

**Assembler Symbols**

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the signed immediate byte offset, in the range -256 to 255, encoded in the "imm9" field.
- <pimm> Is the optional positive immediate byte offset, in the range 0 to 4095, defaulting to 0 and encoded in the "imm12" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
MemOp memop;
boolean signed;
integer regsize;

if opc<1> == '0' then
    // store or zero-extending load
    memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;
    regsize = 32;
    signed = FALSE;
else
    // sign-extending load
    memop = MemOp_LOAD;
    regsize = if opc<0> == '1' then 32 else 64;
    signed = TRUE;

boolean tag_checked = memop != MemOp_PREFETCH && (wback || n != 31);

boolean wb_unknown = FALSE;
boolean rt_unknown = FALSE;

if memop == MemOp_LOAD && wback && n == t && n != 31 then
    c = ConstrainUnpredictable(Unpredictable_WBOVERLAPLD);
    assert c IN {Constraint_WBSUPPRESS, Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_WBSUPPRESS wback = FALSE;    // writeback is suppressed
        when Constraint_UNKNOWN    wb_unknown = TRUE; // writeback is UNKNOWN
        when Constraint_UNDEF      UNDEFINED;
        when Constraint_NOP        EndOfInstruction();

if memop == MemOp_STORE && wback && n == t && n != 31 then
    c = ConstrainUnpredictable(Unpredictable_WBOVERLAPST);
    assert c IN {Constraint_NONE, Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_NONE    rt_unknown = FALSE; // value stored is original value
        when Constraint_UNKNOWN rt_unknown = TRUE;  // value stored is UNKNOWN
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(8) data;

if n == 31 then
    if memop != MemOp_PREFETCH then CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

case memop of
    when MemOp_STORE
        if rt_unknown then
            data = bits(8) UNKNOWN;
        else
            data = X[t];
            Mem[address, 1, AccType_NORMAL] = data;

    when MemOp_LOAD
        data = Mem[address, 1, AccType_NORMAL];
        if signed then
            X[t] = SignExtend(data, regsize);
        else
            X[t] = ZeroExtend(data, regsize);

    when MemOp_PREFETCH
        Prefetch(address, t<4:0>);

if wback then
    if wb_unknown then
        address = bits(64) UNKNOWN;
    elsif postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LDRSB (register)

Load Register Signed Byte (register) calculates an address from a base register value and an offset register value, loads a byte from memory, sign-extends it, and writes it to a register. For information about memory accesses, see [Load/Store addressing modes](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	1	x	1									option	S	1	0									
size								opc								Rm								Rn							

### 32-bit with extended register offset (opc == 11 && option != 011)

LDRSB <Wt>, [<Xn|SP>, (<Wm>|<Xm>), <extend> {<amount>}]

### 32-bit with shifted register offset (opc == 11 && option == 011)

LDRSB <Wt>, [<Xn|SP>, <Xm>{, LSL <amount>}]

### 64-bit with extended register offset (opc == 10 && option != 011)

LDRSB <Xt>, [<Xn|SP>, (<Wm>|<Xm>), <extend> {<amount>}]

### 64-bit with shifted register offset (opc == 10 && option == 011)

LDRSB <Xt>, [<Xn|SP>, <Xm>{, LSL <amount>}]

```
if option<1> == '0' then UNDEFINED; // sub-word index
ExtendType extend_type = DecodeRegExtend(option);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Wm> When option<0> is set to 0, is the 32-bit name of the general-purpose index register, encoded in the "Rm" field.
- <Xm> When option<0> is set to 1, is the 64-bit name of the general-purpose index register, encoded in the "Rm" field.
- <extend> Is the index extend specifier, encoded in "option":

option	<extend>
010	UXTW
110	SXTW
111	SCTX

- <amount> Is the index shift amount, it must be #0, encoded in "S" as 0 if omitted, or as 1 if present.



## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer m = UInt(Rm);
MemOp memop;
boolean signed;
integer regsize;

if opc<1> == '0' then
    // store or zero-extending load
    memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;
    regsize = 32;
    signed = FALSE;
else
    // sign-extending load
    memop = MemOp_LOAD;
    regsize = if opc<0> == '1' then 32 else 64;
    signed = TRUE;

boolean tag_checked = memop != MemOp_PREFETCH;
```

## Operation

```
bits(64) offset = ExtendReg(m, extend_type, 0);
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(8) data;

if n == 31 then
    if memop != MemOp_PREFETCH then CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

case memop of
    when MemOp_STORE
        data = X[t];
        Mem[address, 1, AccType_NORMAL] = data;

    when MemOp_LOAD
        data = Mem[address, 1, AccType_NORMAL];
        if signed then
            X[t] = SignExtend(data, regsize);
        else
            X[t] = ZeroExtend(data, regsize);

    when MemOp_PREFETCH
        Prefetch(address, t<4:0>);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDRSH (immediate)

Load Register Signed Halfword (immediate) loads a halfword from memory, sign-extends it to 32 bits or 64 bits, and writes the result to a register. The address that is used for the load is calculated from a base register and an immediate offset. For information about memory accesses, see [Load/Store addressing modes](#).

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Unsigned offset](#)

## Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	1	x	0	imm9									0	1	Rn				Rt					
size										opc																					

### 32-bit (opc == 11)

LDRSH <Wt>, [<Xn|SP>], #<sim>

### 64-bit (opc == 10)

LDRSH <Xt>, [<Xn|SP>], #<sim>

```
boolean wback = TRUE;
boolean postindex = TRUE;
bits(64) offset = SignExtend(imm9, 64);
```

## Pre-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	1	x	0	imm9									1	1	Rn				Rt					
size										opc																					

### 32-bit (opc == 11)

LDRSH <Wt>, [<Xn|SP>, #<sim>]!

### 64-bit (opc == 10)

LDRSH <Xt>, [<Xn|SP>, #<sim>]!

```
boolean wback = TRUE;
boolean postindex = FALSE;
bits(64) offset = SignExtend(imm9, 64);
```

## Unsigned offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	1	1	x	imm12												Rn				Rt					
size										opc																					

**32-bit (opc == 11)**

```
LDRSH <Wt>, [<Xn|SP>{, #<pimm>}]
```

**64-bit (opc == 10)**

```
LDRSH <Xt>, [<Xn|SP>{, #<pimm>}]
```

```
boolean wback = FALSE;
boolean postindex = FALSE;
bits(64) offset = LSL(ZeroExtend(imm12, 64), 1);
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see *Architectural Constraints on UNPREDICTABLE behaviors*, and particularly *LDRSH (immediate)*.

**Assembler Symbols**

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the signed immediate byte offset, in the range -256 to 255, encoded in the "imm9" field.
- <pimm> Is the optional positive immediate byte offset, a multiple of 2 in the range 0 to 8190, defaulting to 0 and encoded in the "imm12" field as <pimm>/2.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
MemOp memop;
boolean signed;
integer regsize;

if opc<1> == '0' then
    // store or zero-extending load
    memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;
    regsize = 32;
    signed = FALSE;
else
    // sign-extending load
    memop = MemOp_LOAD;
    regsize = if opc<0> == '1' then 32 else 64;
    signed = TRUE;

boolean tag_checked = memop != MemOp_PREFETCH && (wback || n != 31);

boolean wb_unknown = FALSE;
boolean rt_unknown = FALSE;

if memop == MemOp_LOAD && wback && n == t && n != 31 then
    c = ConstrainUnpredictable(Unpredictable_WBOVERLAPLD);
    assert c IN {Constraint_WBSUPPRESS, Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_WBSUPPRESS wback = FALSE;    // writeback is suppressed
        when Constraint_UNKNOWN    wb_unknown = TRUE; // writeback is UNKNOWN
        when Constraint_UNDEF      UNDEFINED;
        when Constraint_NOP        EndOfInstruction();

if memop == MemOp_STORE && wback && n == t && n != 31 then
    c = ConstrainUnpredictable(Unpredictable_WBOVERLAPST);
    assert c IN {Constraint_NONE, Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_NONE    rt_unknown = FALSE; // value stored is original value
        when Constraint_UNKNOWN rt_unknown = TRUE;   // value stored is UNKNOWN
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(16) data;

if n == 31 then
    if memop != MemOp_PREFETCH then CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

case memop of
    when MemOp_STORE
        if rt_unknown then
            data = bits(16) UNKNOWN;
        else
            data = X[t];
            Mem[address, 2, AccType_NORMAL] = data;

    when MemOp_LOAD
        data = Mem[address, 2, AccType_NORMAL];
        if signed then
            X[t] = SignExtend(data, regsize);
        else
            X[t] = ZeroExtend(data, regsize);

    when MemOp_PREFETCH
        Prefetch(address, t<4:0>);

if wback then
    if wb_unknown then
        address = bits(64) UNKNOWN;
    elsif postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

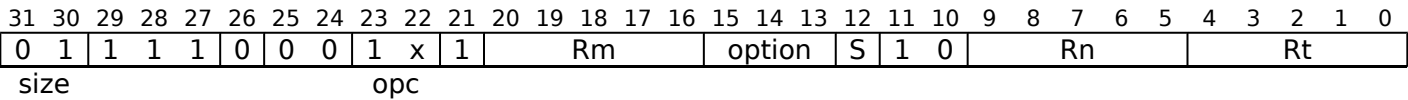
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

LDRSH (register)

Load Register Signed Halfword (register) calculates an address from a base register value and an offset register value, loads a halfword from memory, sign-extends it, and writes it to a register. For information about memory accesses see [Load/Store addressing modes](#).



32-bit (opc == 11)

```
LDRSH <Wt>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]
```

64-bit (opc == 10)

```
LDRSH <Xt>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]
```

```
if option<1> == '0' then UNDEFINED; // sub-word index
ExtendType extend_type = DecodeRegExtend(option);
integer shift = if S == '1' then 1 else 0;
```

Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Wm> When option<0> is set to 0, is the 32-bit name of the general-purpose index register, encoded in the "Rm" field.
- <Xm> When option<0> is set to 1, is the 64-bit name of the general-purpose index register, encoded in the "Rm" field.
- <extend> Is the index extend/shift specifier, defaulting to LSL, and which must be omitted for the LSL option when <amount> is omitted. encoded in "option":

option	<extend>
010	UXTW
011	LSL
110	SXTW
111	SCTX

- <amount> Is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in "S":

S	<amount>
0	#0
1	#1

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer m = UInt(Rm);
MemOp memop;
boolean signed;
integer regsize;

if opc<1> == '0' then
    // store or zero-extending load
    memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;
    regsize = 32;
    signed = FALSE;
else
    // sign-extending load
    memop = MemOp_LOAD;
    regsize = if opc<0> == '1' then 32 else 64;
    signed = TRUE;

boolean tag_checked = memop != MemOp_PREFETCH;
```

## Operation

```
bits(64) offset = ExtendReg(m, extend_type, shift);
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(16) data;

if n == 31 then
    if memop != MemOp_PREFETCH then CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

case memop of
    when MemOp_STORE
        data = X[t];
        Mem[address, 2, AccType_NORMAL] = data;

    when MemOp_LOAD
        data = Mem[address, 2, AccType_NORMAL];
        if signed then
            X[t] = SignExtend(data, regsize);
        else
            X[t] = ZeroExtend(data, regsize);

    when MemOp_PREFETCH
        Prefetch(address, t<4:0>);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

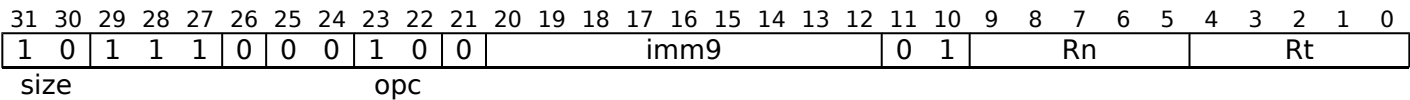
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDRSW (immediate)

Load Register Signed Word (immediate) loads a word from memory, sign-extends it to 64 bits, and writes the result to a register. The address that is used for the load is calculated from a base register and an immediate offset. For information about memory accesses, see [Load/Store addressing modes](#).

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Unsigned offset](#)

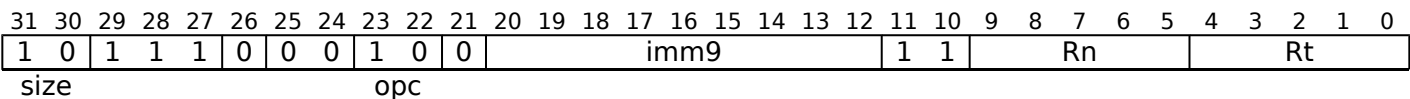
## Post-index



LDRSW <Xt>, [<Xn|SP>], #<sim>

```
boolean wback = TRUE;
boolean postindex = TRUE;
bits(64) offset = SignExtend(imm9, 64);
```

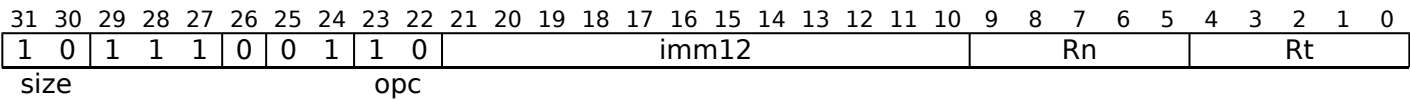
## Pre-index



LDRSW <Xt>, [<Xn|SP>, #<sim>]!

```
boolean wback = TRUE;
boolean postindex = FALSE;
bits(64) offset = SignExtend(imm9, 64);
```

## Unsigned offset



LDRSW <Xt>, [<Xn|SP>{, #<pimm>}]

```
boolean wback = FALSE;
boolean postindex = FALSE;
bits(64) offset = LSL(ZeroExtend(imm12, 64), 2);
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [LDRSW \(immediate\)](#).

## Assembler Symbols

- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the signed immediate byte offset, in the range -256 to 255, encoded in the "imm9" field.
- <pimm> Is the optional positive immediate byte offset, a multiple of 4 in the range 0 to 16380, defaulting to 0 and encoded in the "imm12" field as <pimm>/4.



## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = wback || n != 31;

boolean wb_unknown = FALSE;

if wback && n == t && n != 31 then
    c = ConstrainUnpredictable(Unpredictable_WBOVERLAPLD);
    assert c IN {Constraint_WBSUPPRESS, Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_WBSUPPRESS wback = FALSE;    // writeback is suppressed
        when Constraint_UNKNOWN    wb_unknown = TRUE; // writeback is UNKNOWN
        when Constraint_UNDEF      UNDEFINED;
        when Constraint_NOP        EndOfInstruction();
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(32) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

data = Mem[address, 4, AccType_NORMAL];
X[t] = SignExtend(data, 64);
if wback then
    if wb_unknown then
        address = bits(64) UNKNOWN;
    elsif postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

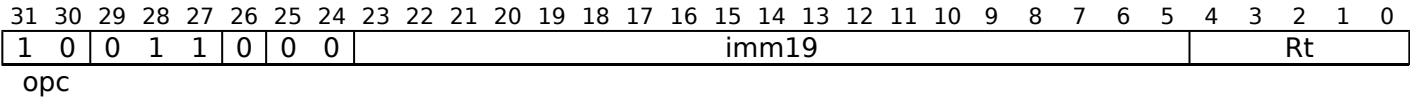
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDRSW (literal)

Load Register Signed Word (literal) calculates an address from the PC value and an immediate offset, loads a word from memory, and writes it to a register. For information about memory accesses, see [Load/Store addressing modes](#).



LDRSW <Xt>, <label>

```
integer t = UInt(Rt);
bits(64) offset;

offset = SignExtend(imm19:'00', 64);
```

## Assembler Symbols

- <Xt> Is the 64-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <label> Is the program label from which the data is to be loaded. Its offset from the address of this instruction, in the range +/-1MB, is encoded as "imm19" times 4.

## Operation

```
bits(64) address = PC[] + offset;
bits(32) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(FALSE);

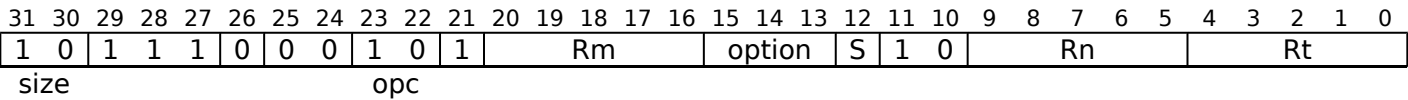
data = Mem[address, 4, AccType_NORMAL];
X[t] = SignExtend(data, 64);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

LDRSW (register)

Load Register Signed Word (register) calculates an address from a base register value and an offset register value, loads a word from memory, sign-extends it to form a 64-bit value, and writes it to a register. The offset register value can be shifted left by 0 or 2 bits. For information about memory accesses, see [Load/Store addressing modes](#).



LDRSW <Xt>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]

```
if option<1> == '0' then UNDEFINED;    // sub-word index
ExtendType extend_type = DecodeRegExtend(option);
integer shift = if S == '1' then 2 else 0;
```

Assembler Symbols

- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Wm> When option<0> is set to 0, is the 32-bit name of the general-purpose index register, encoded in the "Rm" field.
- <Xm> When option<0> is set to 1, is the 64-bit name of the general-purpose index register, encoded in the "Rm" field.
- <extend> Is the index extend/shift specifier, defaulting to LSL, and which must be omitted for the LSL option when <amount> is omitted. encoded in "option":

option	<extend>
010	UXTW
011	LSL
110	SXTW
111	SCTX

<amount> Is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in "S":

S	<amount>
0	#0
1	#2

Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer m = UInt(Rm);
```

## Operation

```
bits(64) offset = ExtendReg(m, extend_type, shift);
if HaveMTE2Ext() then
    SetTagCheckedInstruction(TRUE);

bits(64) address;
bits(32) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = Mem[address, 4, AccType_NORMAL];
X[t] = SignExtend(data, 64);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDSET, LDSETA, LDSETAL, LDSETL

Atomic bit set on word or doubleword in memory atomically loads a 32-bit word or 64-bit doubleword from memory, performs a bitwise OR with the value held in a register on it, and stores the result back to memory. The value initially loaded from memory is returned in the destination register.

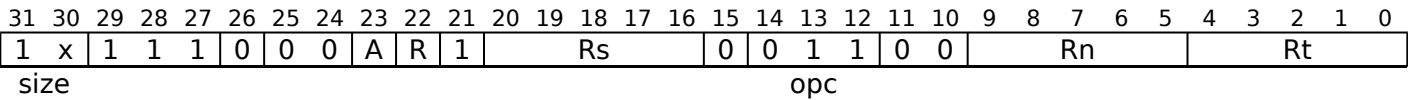
- If the destination register is not one of WZR or XZR, LDSETA and LDSETAL load from memory with acquire semantics.
- LDSETL and LDSETAL store to memory with release semantics.
- LDSET has neither acquire nor release semantics.

For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This instruction is used by the alias *STSET, STSETL*.

## Integer (FEAT\_LSE)



**32-bit LDSET (size == 10 && A == 0 && R == 0)**

LDSET <Ws>, <Wt>, [<Xn|SP>]

**32-bit LDSETA (size == 10 && A == 1 && R == 0)**

LDSETA <Ws>, <Wt>, [<Xn|SP>]

**32-bit LDSETAL (size == 10 && A == 1 && R == 1)**

LDSETAL <Ws>, <Wt>, [<Xn|SP>]

**32-bit LDSETL (size == 10 && A == 0 && R == 1)**

LDSETL <Ws>, <Wt>, [<Xn|SP>]

**64-bit LDSET (size == 11 && A == 0 && R == 0)**

LDSET <Xs>, <Xt>, [<Xn|SP>]

**64-bit LDSETA (size == 11 && A == 1 && R == 0)**

LDSETA <Xs>, <Xt>, [<Xn|SP>]

**64-bit LDSETAL (size == 11 && A == 1 && R == 1)**

LDSETAL <Xs>, <Xt>, [<Xn|SP>]

**64-bit LDSETL (size == 11 && A == 0 && R == 1)**

LDSETL <Xs>, <Xt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

integer datasize = 8 << UInt(size);
integer regsize = if datasize == 64 then 64 else 32;
AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

**Assembler Symbols**

<Ws>	Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Wt>	Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
<Xs>	Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xt>	Is the 64-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

**Alias Conditions**

Alias	Is preferred when
<a href="#">STSET, STSETL</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(datasize) value;
bits(datasize) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_ORR, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, regsize);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

LDSETB, LDSETAB, LDSETALB, LDSETLB

Atomic bit set on byte in memory atomically loads an 8-bit byte from memory, performs a bitwise OR with the value held in a register on it, and stores the result back to memory. The value initially loaded from memory is returned in the destination register.

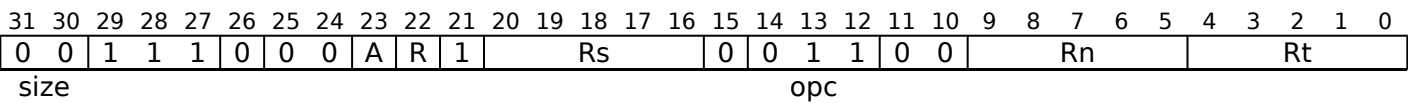
- If the destination register is not WZR, LDSETAB and LDSETALB load from memory with acquire semantics.
- LDSETLB and LDSETALB store to memory with release semantics.
- LDSETB has neither acquire nor release semantics.

For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This instruction is used by the alias *STSETB, STSETLB*.

Integer  
(FEAT\_LSE)



LDSETAB (A == 1 && R == 0)

```
LDSETAB <Ws>, <Wt>, [<Xn|SP>]
```

LDSETALB (A == 1 && R == 1)

```
LDSETALB <Ws>, <Wt>, [<Xn|SP>]
```

LDSETB (A == 0 && R == 0)

```
LDSETB <Ws>, <Wt>, [<Xn|SP>]
```

LDSETLB (A == 0 && R == 1)

```
LDSETLB <Ws>, <Wt>, [<Xn|SP>]
```

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Alias Conditions

Alias	Is preferred when
<a href="#">STSETB, STSETLB</a>	A == '0' && Rt == '11111'



## Operation

```
bits(64) address;
bits(8) value;
bits(8) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_ORR, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

LDSETH, LDSETAH, LDSETALH, LDSETLH

Atomic bit set on halfword in memory atomically loads a 16-bit halfword from memory, performs a bitwise OR with the value held in a register on it, and stores the result back to memory. The value initially loaded from memory is returned in the destination register.

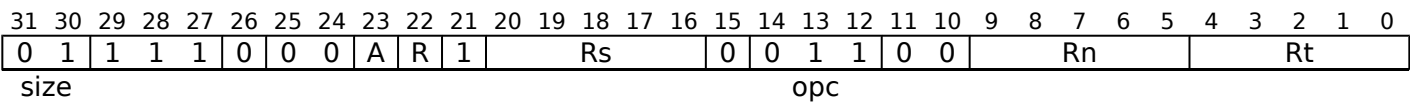
- If the destination register is not WZR, LDSETAH and LDSETALH load from memory with acquire semantics.
- LDSETLH and LDSETALH store to memory with release semantics.
- LDSETH has neither acquire nor release semantics.

For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This instruction is used by the alias *STSETH, STSETLH*.

Integer  
(FEAT\_LSE)



LDSETAH (A == 1 && R == 0)

LDSETAH <Ws>, <Wt>, [<Xn|SP>]

LDSETALH (A == 1 && R == 1)

LDSETALH <Ws>, <Wt>, [<Xn|SP>]

LDSETH (A == 0 && R == 0)

LDSETH <Ws>, <Wt>, [<Xn|SP>]

LDSETLH (A == 0 && R == 1)

LDSETLH <Ws>, <Wt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Alias Conditions

Alias	Is preferred when
<a href="#">STSETH, STSETLH</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(16) value;
bits(16) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_ORR, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDSMAX, LDSMAXA, LDSMAXAL, LDSMAXL

Atomic signed maximum on word or doubleword in memory atomically loads a 32-bit word or 64-bit doubleword from memory, compares it against the value held in a register, and stores the larger value back to memory, treating the values as signed numbers. The value initially loaded from memory is returned in the destination register.

- If the destination register is not one of WZR or XZR, LDSMAXA and LDSMAXAL load from memory with acquire semantics.
- LDSMAXL and LDSMAXAL store to memory with release semantics.
- LDSMAX has neither acquire nor release semantics.

For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This instruction is used by the alias *STSMAX, STSMAXL*.

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	0	A	R	1	Rs				0	1	0	0	0	0	Rn				Rt						
size												opc																			

**32-bit LDSMAX (size == 10 && A == 0 && R == 0)**

```
LDSMAX <Ws>, <Wt>, [<Xn|SP>]
```

**32-bit LDSMAXA (size == 10 && A == 1 && R == 0)**

```
LDSMAXA <Ws>, <Wt>, [<Xn|SP>]
```

**32-bit LDSMAXAL (size == 10 && A == 1 && R == 1)**

```
LDSMAXAL <Ws>, <Wt>, [<Xn|SP>]
```

**32-bit LDSMAXL (size == 10 && A == 0 && R == 1)**

```
LDSMAXL <Ws>, <Wt>, [<Xn|SP>]
```

**64-bit LDSMAX (size == 11 && A == 0 && R == 0)**

```
LDSMAX <Xs>, <Xt>, [<Xn|SP>]
```

**64-bit LDSMAXA (size == 11 && A == 1 && R == 0)**

```
LDSMAXA <Xs>, <Xt>, [<Xn|SP>]
```

**64-bit LDSMAXAL (size == 11 && A == 1 && R == 1)**

```
LDSMAXAL <Xs>, <Xt>, [<Xn|SP>]
```

**64-bit LDSMAXL (size == 11 && A == 0 && R == 1)**

```
LDSMAXL <Xs>, <Xt>, [<Xn|SP>]
```

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

integer datasize = 8 << UInt(size);
integer regsize = if datasize == 64 then 64 else 32;
AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

**Assembler Symbols**

<Ws>	Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Wt>	Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
<Xs>	Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xt>	Is the 64-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

**Alias Conditions**

Alias	Is preferred when
<a href="#">STSMAX</a> , <a href="#">STSMAXL</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(datasize) value;
bits(datasize) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_SMAX, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, regsize);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDSMAXB, LDSMAXAB, LDSMAXALB, LDSMAXLB

Atomic signed maximum on byte in memory atomically loads an 8-bit byte from memory, compares it against the value held in a register, and stores the larger value back to memory, treating the values as signed numbers. The value initially loaded from memory is returned in the destination register.

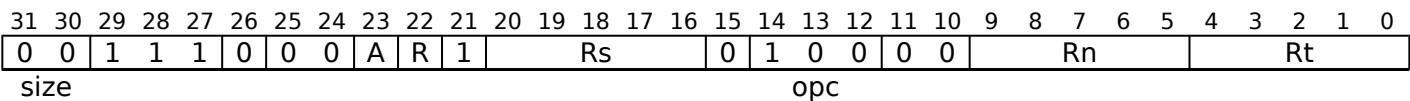
- If the destination register is not WZR, LDSMAXAB and LDSMAXALB load from memory with acquire semantics.
- LDSMAXLB and LDSMAXALB store to memory with release semantics.
- LDSMAXB has neither acquire nor release semantics.

For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This instruction is used by the alias [STSMAXB, STSMAXLB](#).

## Integer (FEAT\_LSE)



### LDSMAXAB (A == 1 && R == 0)

LDSMAXAB <Ws>, <Wt>, [<Xn|SP>]

### LDSMAXALB (A == 1 && R == 1)

LDSMAXALB <Ws>, <Wt>, [<Xn|SP>]

### LDSMAXB (A == 0 && R == 0)

LDSMAXB <Ws>, <Wt>, [<Xn|SP>]

### LDSMAXLB (A == 0 && R == 1)

LDSMAXLB <Ws>, <Wt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">STSMAXB, STSMAXLB</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(8) value;
bits(8) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_SMAX, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# LDSMAXH, LDSMAXAH, LDSMAXALH, LDSMAXLH

Atomic signed maximum on halfword in memory atomically loads a 16-bit halfword from memory, compares it against the value held in a register, and stores the larger value back to memory, treating the values as signed numbers. The value initially loaded from memory is returned in the destination register.

- If the destination register is not WZR, LDSMAXAH and LDSMAXALH load from memory with acquire semantics.
- LDSMAXLH and LDSMAXALH store to memory with release semantics.
- LDSMAXH has neither acquire nor release semantics.

For more information about memory ordering semantics see [Load-Acquire, Store-Release](#).

For information about memory accesses see [Load/Store addressing modes](#).

This instruction is used by the alias [STSMAXH, STSMAXLH](#).

## Integer

(FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	A	R	1	Rs					0	1	0	0	0	0	Rn					Rt				
size											opc																				

### LDSMAXAH (A == 1 && R == 0)

LDSMAXAH <Ws>, <Wt>, [<Xn|SP>]

### LDSMAXALH (A == 1 && R == 1)

LDSMAXALH <Ws>, <Wt>, [<Xn|SP>]

### LDSMAXH (A == 0 && R == 0)

LDSMAXH <Ws>, <Wt>, [<Xn|SP>]

### LDSMAXLH (A == 0 && R == 1)

LDSMAXLH <Ws>, <Wt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

<Ws>	Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Wt>	Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">STSMAXH, STSMAXLH</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(16) value;
bits(16) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_SMAX, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDSMIN, LDSMINA, LDSMINAL, LDSMINL

Atomic signed minimum on word or doubleword in memory atomically loads a 32-bit word or 64-bit doubleword from memory, compares it against the value held in a register, and stores the smaller value back to memory, treating the values as signed numbers. The value initially loaded from memory is returned in the destination register.

- If the destination register is not one of WZR or XZR, LDSMINA and LDSMINAL load from memory with acquire semantics.
- LDSMINL and LDSMINAL store to memory with release semantics.
- LDSMIN has neither acquire nor release semantics.

For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This instruction is used by the alias *STSMIN, STSMINL*.

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	0	A	R	1	Rs				0	1	0	1	0	0	Rn				Rt						
size												opc																			

**32-bit LDSMIN (size == 10 && A == 0 && R == 0)**

LDSMIN <Ws>, <Wt>, [<Xn|SP>]

**32-bit LDSMINA (size == 10 && A == 1 && R == 0)**

LDSMINA <Ws>, <Wt>, [<Xn|SP>]

**32-bit LDSMINAL (size == 10 && A == 1 && R == 1)**

LDSMINAL <Ws>, <Wt>, [<Xn|SP>]

**32-bit LDSMINL (size == 10 && A == 0 && R == 1)**

LDSMINL <Ws>, <Wt>, [<Xn|SP>]

**64-bit LDSMIN (size == 11 && A == 0 && R == 0)**

LDSMIN <Xs>, <Xt>, [<Xn|SP>]

**64-bit LDSMINA (size == 11 && A == 1 && R == 0)**

LDSMINA <Xs>, <Xt>, [<Xn|SP>]

**64-bit LDSMINAL (size == 11 && A == 1 && R == 1)**

LDSMINAL <Xs>, <Xt>, [<Xn|SP>]

**64-bit LDSMINL (size == 11 && A == 0 && R == 1)**

LDSMINL <Xs>, <Xt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

integer datasize = 8 << UInt(size);
integer regsize = if datasize == 64 then 64 else 32;
AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

**Assembler Symbols**

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xs> Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xt> Is the 64-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

**Alias Conditions**

Alias	Is preferred when
<a href="#">STSMIN</a> , <a href="#">STSMINL</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(datasize) value;
bits(datasize) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_SMIN, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, regsize);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDSMINB, LDSMINAB, LDSMINALB, LDSMINLB

Atomic signed minimum on byte in memory atomically loads an 8-bit byte from memory, compares it against the value held in a register, and stores the smaller value back to memory, treating the values as signed numbers. The value initially loaded from memory is returned in the destination register.

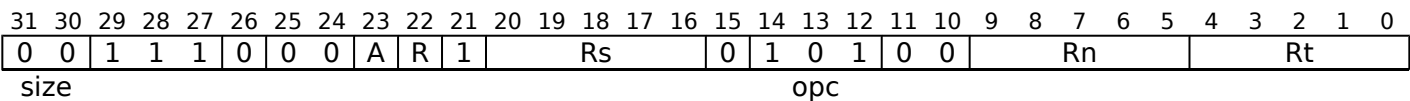
- If the destination register is not WZR, LDSMINAB and LDSMINALB load from memory with acquire semantics.
- LDSMINLB and LDSMINALB store to memory with release semantics.
- LDSMINB has neither acquire nor release semantics.

For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This instruction is used by the alias [STSMINB, STSMINLB](#).

## Integer (FEAT\_LSE)



### LDSMINAB (A == 1 && R == 0)

LDSMINAB <Ws>, <Wt>, [[<Xn|SP>](#)]

### LDSMINALB (A == 1 && R == 1)

LDSMINALB <Ws>, <Wt>, [[<Xn|SP>](#)]

### LDSMINB (A == 0 && R == 0)

LDSMINB <Ws>, <Wt>, [[<Xn|SP>](#)]

### LDSMINLB (A == 0 && R == 1)

LDSMINLB <Ws>, <Wt>, [[<Xn|SP>](#)]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">STSMINB, STSMINLB</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(8) value;
bits(8) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_SMIN, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDSMINH, LDSMINAH, LDSMINALH, LDSMINLH

Atomic signed minimum on halfword in memory atomically loads a 16-bit halfword from memory, compares it against the value held in a register, and stores the smaller value back to memory, treating the values as signed numbers. The value initially loaded from memory is returned in the destination register.

- If the destination register is not WZR, LDSMINAH and LDSMINALH load from memory with acquire semantics.
- LDSMINLH and LDSMINALH store to memory with release semantics.
- LDSMINH has neither acquire nor release semantics.

For more information about memory ordering semantics see [Load-Acquire, Store-Release](#).

For information about memory accesses see [Load/Store addressing modes](#).

This instruction is used by the alias [STSMINH, STSMINLH](#).

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	A	R	1	Rs					0	1	0	1	0	0	Rn					Rt				
size											opc																				

### LDSMINAH (A == 1 && R == 0)

LDSMINAH <Ws>, <Wt>, [[<Xn|SP>](#)]

### LDSMINALH (A == 1 && R == 1)

LDSMINALH <Ws>, <Wt>, [[<Xn|SP>](#)]

### LDSMINH (A == 0 && R == 0)

LDSMINH <Ws>, <Wt>, [[<Xn|SP>](#)]

### LDSMINLH (A == 0 && R == 1)

LDSMINLH <Ws>, <Wt>, [[<Xn|SP>](#)]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType\_ORDEREDATOMICRW else AccType\_ATOMICRW;
AccType stacctype = if R == '1' then AccType\_ORDEREDATOMICRW else AccType\_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">STSMINH, STSMINLH</a>	A == '0' && Rt == '11111'



## Operation

```
bits(64) address;
bits(16) value;
bits(16) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_SMIN, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

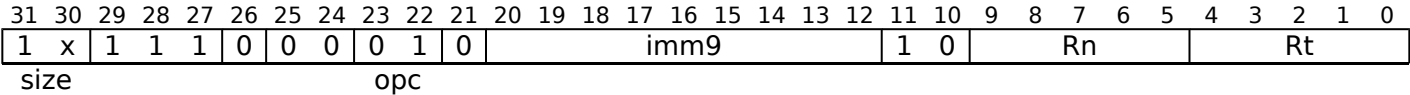
# LDTR

Load Register (unprivileged) loads a word or doubleword from memory, and writes it to a register. The address that is used for the load is calculated from a base register and an immediate offset.

Memory accesses made by the instruction behave as if the instruction was executed at EL0 if the *Effective value* of PSTATE.UAO is 0 and either:

- The instruction is executed at EL1.
- The instruction is executed at EL2 when the *Effective value* of HCR\_EL2.{E2H, TGE} is {1, 1}.

Otherwise, the memory access operates with the restrictions determined by the Exception level at which the instruction is executed. For information about memory accesses, see *Load/Store addressing modes*.



## 32-bit (size == 10)

```
LDTR <Wt>, [<Xn|SP>{, #<sim>}]
```

## 64-bit (size == 11)

```
LDTR <Xt>, [<Xn|SP>{, #<sim>}]
```

```
integer scale = UInt(size);
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

unpriv_at_el1 = PSTATE.EL == EL1 && !(EL2Enabled() && HaveNVExt() && HCR_EL2.<NV,NV1> == '11');
unpriv_at_el2 = PSTATE.EL == EL2 && HaveVirtHostExt() && HCR_EL2.<E2H,TGE> == '11';

user_access_override = HaveUA0Ext() && PSTATE.UAO == '1';
if !user_access_override && (unpriv_at_el1 || unpriv_at_el2) then
    acctype = AccType_UNPRIV;
else
    acctype = AccType_NORMAL;

integer regsize;

regsize = if size == '11' then 64 else 32;
integer datasize = 8 << scale;
boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(datasize) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = Mem[address, datasize DIV 8, acctype];
X[t] = ZeroExtend(data, regsize);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LDTRB

Load Register Byte (unprivileged) loads a byte from memory, zero-extends it, and writes the result to a register. The address that is used for the load is calculated from a base register and an immediate offset.

Memory accesses made by the instruction behave as if the instruction was executed at EL0 if the *Effective value* of PSTATE.UAO is 0 and either:

- The instruction is executed at EL1.
- The instruction is executed at EL2 when the *Effective value* of HCR\_EL2.{E2H, TGE} is {1, 1}.

Otherwise, the memory access operates with the restrictions determined by the Exception level at which the instruction is executed. For information about memory accesses, see *Load/Store addressing modes*.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0											
0		0		1		1		1		0		0		0		0		1		0		imm9									1		0		Rn				Rt			
size											opc																															

LDTRB <Wt>, [<Xn|SP>{, #<sim>}]

```
bits(64) offset = SignExtend(imm9, 64);
```

### Assembler Symbols

<Wt>	Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<sim>	Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

### Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

unpriv_at_el1 = PSTATE.EL == EL1 && !(EL2Enabled() && HaveNVExt() && HCR_EL2.<NV,NV1> == '11');
unpriv_at_el2 = PSTATE.EL == EL2 && HaveVirtHostExt() && HCR_EL2.<E2H,TGE> == '11';

user_access_override = HaveUA0Ext() && PSTATE.UAO == '1';
if !user_access_override && (unpriv_at_el1 || unpriv_at_el2) then
    acctype = AccType_UNPRIV;
else
    acctype = AccType_NORMAL;

boolean tag_checked = n != 31;
```

### Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(8) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = Mem[address, 1, acctype];
X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LDTRH

Load Register Halfword (unprivileged) loads a halfword from memory, zero-extends it, and writes the result to a register. The address that is used for the load is calculated from a base register and an immediate offset.

Memory accesses made by the instruction behave as if the instruction was executed at EL0 if the *Effective value* of PSTATE.UAO is 0 and either:

- The instruction is executed at EL1.
- The instruction is executed at EL2 when the *Effective value* of HCR\_EL2.{E2H, TGE} is {1, 1}.

Otherwise, the memory access operates with the restrictions determined by the Exception level at which the instruction is executed. For information about memory accesses, see *Load/Store addressing modes*.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	0	1	0	imm9									1	0	Rn				Rt					
size											opc																				

LDTRH <Wt>, [<Xn|SP>{, #<simm>}]

```
bits(64) offset = SignExtend(imm9, 64);
```

### Assembler Symbols

<Wt>	Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<simm>	Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

### Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

unpriv_at_el1 = PSTATE.EL == EL1 && !(EL2Enabled() && HaveNVExt() && HCR_EL2.<NV,NV1> == '11');
unpriv_at_el2 = PSTATE.EL == EL2 && HaveVirtHostExt() && HCR_EL2.<E2H,TGE> == '11';

user_access_override = HaveUA0Ext() && PSTATE.UAO == '1';
if !user_access_override && (unpriv_at_el1 || unpriv_at_el2) then
    acctype = AccType_UNPRIV;
else
    acctype = AccType_NORMAL;

boolean tag_checked = n != 31;
```

### Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(16) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = Mem[address, 2, acctype];
X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

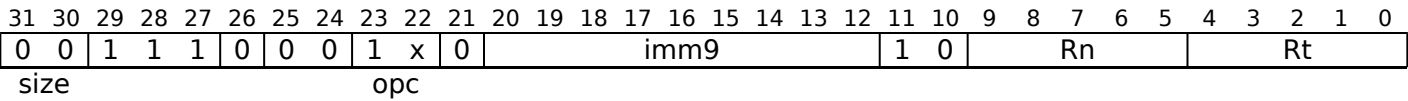
# LDTRSB

Load Register Signed Byte (unprivileged) loads a byte from memory, sign-extends it to 32 bits or 64 bits, and writes the result to a register. The address that is used for the load is calculated from a base register and an immediate offset.

Memory accesses made by the instruction behave as if the instruction was executed at EL0 if the *Effective value* of PSTATE.UAO is 0 and either:

- The instruction is executed at EL1.
- The instruction is executed at EL2 when the *Effective value* of HCR\_EL2.{E2H, TGE} is {1, 1}.

Otherwise, the memory access operates with the restrictions determined by the Exception level at which the instruction is executed. For information about memory accesses, see *Load/Store addressing modes*.



## 32-bit (opc == 11)

```
LDTRSB <Wt>, [<Xn|SP>{, #<simm>}]
```

## 64-bit (opc == 10)

```
LDTRSB <Xt>, [<Xn|SP>{, #<simm>}]
```

```
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <simm> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.



## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

unpriv_at_el1 = PSTATE.EL == EL1 && !(EL2Enabled() && HaveNVExt() && HCR_EL2.<NV,NV1> == '11');
unpriv_at_el2 = PSTATE.EL == EL2 && HaveVirtHostExt() && HCR_EL2.<E2H,TGE> == '11';

user_access_override = HaveUA0Ext() && PSTATE.UAO == '1';
if !user_access_override && (unpriv_at_el1 || unpriv_at_el2) then
    acctype = AccType_UNPRIV;
else
    acctype = AccType_NORMAL;

MemOp memop;
boolean signed;
integer regsize;

if opc<1> == '0' then
    // store or zero-extending load
    memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;
    regsize = 32;
    signed = FALSE;
else
    // sign-extending load
    memop = MemOp_LOAD;
    regsize = if opc<0> == '1' then 32 else 64;
    signed = TRUE;

boolean tag_checked = memop != MemOp_PREFETCH && (n != 31);
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(8) data;

if n == 31 then
    if memop != MemOp_PREFETCH then CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

case memop of
    when MemOp_STORE
        data = X[t];
        Mem[address, 1, acctype] = data;

    when MemOp_LOAD
        data = Mem[address, 1, acctype];
        if signed then
            X[t] = SignExtend(data, regsize);
        else
            X[t] = ZeroExtend(data, regsize);

    when MemOp_PREFETCH
        Prefetch(address, t<4:0>);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

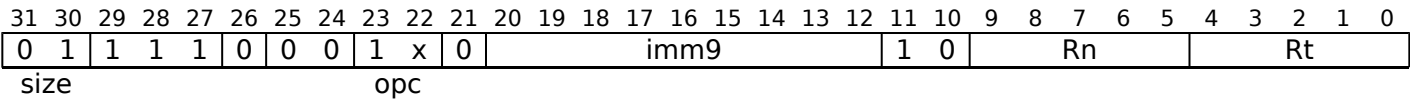
# LDTRSH

Load Register Signed Halfword (unprivileged) loads a halfword from memory, sign-extends it to 32 bits or 64 bits, and writes the result to a register. The address that is used for the load is calculated from a base register and an immediate offset.

Memory accesses made by the instruction behave as if the instruction was executed at EL0 if the *Effective value* of PSTATE.UAO is 0 and either:

- The instruction is executed at EL1.
- The instruction is executed at EL2 when the *Effective value* of HCR\_EL2.{E2H, TGE} is {1, 1}.

Otherwise, the memory access operates with the restrictions determined by the Exception level at which the instruction is executed. For information about memory accesses, see *Load/Store addressing modes*.



## 32-bit (opc == 11)

```
LDTRSH <Wt>, [<Xn|SP>{, #<simm>}]
```

## 64-bit (opc == 10)

```
LDTRSH <Xt>, [<Xn|SP>{, #<simm>}]
```

```
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <simm> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

unpriv_at_el1 = PSTATE.EL == EL1 && !(EL2Enabled() && HaveNVExt() && HCR_EL2.<NV,NV1> == '11');
unpriv_at_el2 = PSTATE.EL == EL2 && HaveVirtHostExt() && HCR_EL2.<E2H,TGE> == '11';

user_access_override = HaveUA0Ext() && PSTATE.UAO == '1';
if !user_access_override && (unpriv_at_el1 || unpriv_at_el2) then
    acctype = AccType_UNPRIV;
else
    acctype = AccType_NORMAL;

MemOp memop;
boolean signed;
integer regsize;

if opc<1> == '0' then
    // store or zero-extending load
    memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;
    regsize = 32;
    signed = FALSE;
else
    // sign-extending load
    memop = MemOp_LOAD;
    regsize = if opc<0> == '1' then 32 else 64;
    signed = TRUE;

boolean tag_checked = memop != MemOp_PREFETCH && (n != 31);
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(16) data;

if n == 31 then
    if memop != MemOp_PREFETCH then CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

case memop of
    when MemOp_STORE
        data = X[t];
        Mem[address, 2, acctype] = data;

    when MemOp_LOAD
        data = Mem[address, 2, acctype];
        if signed then
            X[t] = SignExtend(data, regsize);
        else
            X[t] = ZeroExtend(data, regsize);

    when MemOp_PREFETCH
        Prefetch(address, t<4:0>);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LDTRSW

Load Register Signed Word (unprivileged) loads a word from memory, sign-extends it to 64 bits, and writes the result to a register. The address that is used for the load is calculated from a base register and an immediate offset.

Memory accesses made by the instruction behave as if the instruction was executed at EL0 if the *Effective value* of PSTATE.UAO is 0 and either:

- The instruction is executed at EL1.
- The instruction is executed at EL2 when the *Effective value* of *HCR\_EL2*.{E2H, TGE} is {1, 1}.

Otherwise, the memory access operates with the restrictions determined by the Exception level at which the instruction is executed. For information about memory accesses, see *Load/Store addressing modes*.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	1	1	0	0	0	1	0	0	imm9									1	0	Rn				Rt					
size								opc																							

LDTRSW <Xt>, [<Xn|SP>{, #<simm>}]

```
bits(64) offset = SignExtend(imm9, 64);
```

### Assembler Symbols

<Xt>	Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<simm>	Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

### Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

unpriv_at_el1 = PSTATE.EL == EL1 && !(EL2Enabled() && HaveNVExt() && HCR_EL2.<NV,NV1> == '11');
unpriv_at_el2 = PSTATE.EL == EL2 && HaveVirtHostExt() && HCR_EL2.<E2H,TGE> == '11';

user_access_override = HaveUA0Ext() && PSTATE.UAO == '1';
if !user_access_override && (unpriv_at_el1 || unpriv_at_el2) then
    acctype = AccType_UNPRIV;
else
    acctype = AccType_NORMAL;

boolean tag_checked = n != 31;
```

### Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(32) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = Mem[address, 4, acctype];
X[t] = SignExtend(data, 64);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDUMAX, LDUMAXA, LDUMAXAL, LDUMAXL

Atomic unsigned maximum on word or doubleword in memory atomically loads a 32-bit word or 64-bit doubleword from memory, compares it against the value held in a register, and stores the larger value back to memory, treating the values as unsigned numbers. The value initially loaded from memory is returned in the destination register.

- If the destination register is not one of WZR or XZR, LDUMAXA and LDUMAXAL load from memory with acquire semantics.
- LDUMAXL and LDUMAXAL store to memory with release semantics.
- LDUMAX has neither acquire nor release semantics.

For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This instruction is used by the alias *STUMAX, STUMAXL*.

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	0	A	R	1	Rs				0	1	1	0	0	0	Rn				Rt						
size												opc																			

32-bit LDUMAX (size == 10 && A == 0 && R == 0)

LDUMAX <Ws>, <Wt>, [<Xn|SP>]

32-bit LDUMAXA (size == 10 && A == 1 && R == 0)

LDUMAXA <Ws>, <Wt>, [<Xn|SP>]

32-bit LDUMAXAL (size == 10 && A == 1 && R == 1)

LDUMAXAL <Ws>, <Wt>, [<Xn|SP>]

32-bit LDUMAXL (size == 10 && A == 0 && R == 1)

LDUMAXL <Ws>, <Wt>, [<Xn|SP>]

64-bit LDUMAX (size == 11 && A == 0 && R == 0)

LDUMAX <Xs>, <Xt>, [<Xn|SP>]

64-bit LDUMAXA (size == 11 && A == 1 && R == 0)

LDUMAXA <Xs>, <Xt>, [<Xn|SP>]

64-bit LDUMAXAL (size == 11 && A == 1 && R == 1)

LDUMAXAL <Xs>, <Xt>, [<Xn|SP>]

64-bit LDUMAXL (size == 11 && A == 0 && R == 1)

LDUMAXL <Xs>, <Xt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

integer datasize = 8 << UInt(size);
integer regsize = if datasize == 64 then 64 else 32;
AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

Assembler Symbols

<Ws>	Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Wt>	Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
<Xs>	Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xt>	Is the 64-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Alias Conditions

Alias	Is preferred when
<a href="#">STUMAX, STUMAXL</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(datasize) value;
bits(datasize) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_UMAX, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, regsize);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# LDUMAXB, LDUMAXAB, LDUMAXALB, LDUMAXLB

Atomic unsigned maximum on byte in memory atomically loads an 8-bit byte from memory, compares it against the value held in a register, and stores the larger value back to memory, treating the values as unsigned numbers. The value initially loaded from memory is returned in the destination register.

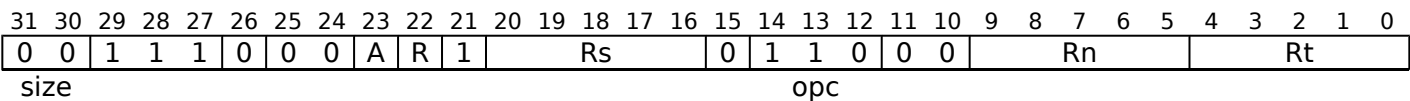
- If the destination register is not WZR, LDUMAXAB and LDUMAXALB load from memory with acquire semantics.
- LDUMAXLB and LDUMAXALB store to memory with release semantics.
- LDUMAXB has neither acquire nor release semantics.

For more information about memory ordering semantics see [Load-Acquire, Store-Release](#).

For information about memory accesses see [Load/Store addressing modes](#).

This instruction is used by the alias [STUMAXB, STUMAXLB](#).

## Integer (FEAT\_LSE)



### LDUMAXAB (A == 1 && R == 0)

LDUMAXAB <Ws>, <Wt>, [<Xn|SP>]

### LDUMAXALB (A == 1 && R == 1)

LDUMAXALB <Ws>, <Wt>, [<Xn|SP>]

### LDUMAXB (A == 0 && R == 0)

LDUMAXB <Ws>, <Wt>, [<Xn|SP>]

### LDUMAXLB (A == 0 && R == 1)

LDUMAXLB <Ws>, <Wt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">STUMAXB, STUMAXLB</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(8) value;
bits(8) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_UMAX, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDUMAXH, LDUMAXAH, LDUMAXALH, LDUMAXLH

Atomic unsigned maximum on halfword in memory atomically loads a 16-bit halfword from memory, compares it against the value held in a register, and stores the larger value back to memory, treating the values as unsigned numbers. The value initially loaded from memory is returned in the destination register.

- If the destination register is not WZR, LDUMAXAH and LDUMAXALH load from memory with acquire semantics.
- LDUMAXLH and LDUMAXALH store to memory with release semantics.
- LDUMAXH has neither acquire nor release semantics.

For more information about memory ordering semantics see [Load-Acquire, Store-Release](#).

For information about memory accesses see [Load/Store addressing modes](#).

This instruction is used by the alias [STUMAXH, STUMAXLH](#).

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	A	R	1	Rs					0	1	1	0	0	0	Rn					Rt				
size											opc																				

### LDUMAXAH (A == 1 && R == 0)

LDUMAXAH <Ws>, <Wt>, [<Xn|SP>]

### LDUMAXALH (A == 1 && R == 1)

LDUMAXALH <Ws>, <Wt>, [<Xn|SP>]

### LDUMAXH (A == 0 && R == 0)

LDUMAXH <Ws>, <Wt>, [<Xn|SP>]

### LDUMAXLH (A == 0 && R == 1)

LDUMAXLH <Ws>, <Wt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">STUMAXH, STUMAXLH</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(16) value;
bits(16) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_UMAX, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDUMIN, LDUMINA, LDUMINAL, LDUMINL

Atomic unsigned minimum on word or doubleword in memory atomically loads a 32-bit word or 64-bit doubleword from memory, compares it against the value held in a register, and stores the smaller value back to memory, treating the values as unsigned numbers. The value initially loaded from memory is returned in the destination register.

- If the destination register is not one of WZR or XZR, LDUMINA and LDUMINAL load from memory with acquire semantics.
- LDUMINL and LDUMINAL store to memory with release semantics.
- LDUMIN has neither acquire nor release semantics.

For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This instruction is used by the alias *STUMIN, STUMINL*.

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	0	A	R	1	Rs				0	1	1	1	0	0	Rn				Rt						
size																opc															

**32-bit LDUMIN (size == 10 && A == 0 && R == 0)**

LDUMIN <Ws>, <Wt>, [<Xn|SP>]

**32-bit LDUMINA (size == 10 && A == 1 && R == 0)**

LDUMINA <Ws>, <Wt>, [<Xn|SP>]

**32-bit LDUMINAL (size == 10 && A == 1 && R == 1)**

LDUMINAL <Ws>, <Wt>, [<Xn|SP>]

**32-bit LDUMINL (size == 10 && A == 0 && R == 1)**

LDUMINL <Ws>, <Wt>, [<Xn|SP>]

**64-bit LDUMIN (size == 11 && A == 0 && R == 0)**

LDUMIN <Xs>, <Xt>, [<Xn|SP>]

**64-bit LDUMINA (size == 11 && A == 1 && R == 0)**

LDUMINA <Xs>, <Xt>, [<Xn|SP>]

**64-bit LDUMINAL (size == 11 && A == 1 && R == 1)**

LDUMINAL <Xs>, <Xt>, [<Xn|SP>]

**64-bit LDUMINL (size == 11 && A == 0 && R == 1)**

LDUMINL <Xs>, <Xt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

integer datasize = 8 << UInt(size);
integer regsize = if datasize == 64 then 64 else 32;
AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

**Assembler Symbols**

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xs> Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xt> Is the 64-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

**Alias Conditions**

Alias	Is preferred when
<a href="#">STUMIN</a> , <a href="#">STUMINL</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(datasize) value;
bits(datasize) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_UMIN, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, regsize);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDUMINB, LDUMINAB, LDUMINALB, LDUMINLB

Atomic unsigned minimum on byte in memory atomically loads an 8-bit byte from memory, compares it against the value held in a register, and stores the smaller value back to memory, treating the values as unsigned numbers. The value initially loaded from memory is returned in the destination register.

- If the destination register is not WZR, LDUMINAB and LDUMINALB load from memory with acquire semantics.
- LDUMINLB and LDUMINALB store to memory with release semantics.
- LDUMINB has neither acquire nor release semantics.

For more information about memory ordering semantics see [Load-Acquire, Store-Release](#).

For information about memory accesses see [Load/Store addressing modes](#).

This instruction is used by the alias [STUMINB, STUMINLB](#).

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	A	R	1	Rs					0	1	1	1	0	0	Rn					Rt				
size											opc																				

### LDUMINAB (A == 1 && R == 0)

LDUMINAB <Ws>, <Wt>, [<Xn|SP>]

### LDUMINALB (A == 1 && R == 1)

LDUMINALB <Ws>, <Wt>, [<Xn|SP>]

### LDUMINB (A == 0 && R == 0)

LDUMINB <Ws>, <Wt>, [<Xn|SP>]

### LDUMINLB (A == 0 && R == 1)

LDUMINLB <Ws>, <Wt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">STUMINB, STUMINLB</a>	A == '0' && Rt == '11111'



## Operation

```
bits(64) address;
bits(8) value;
bits(8) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_UMIN, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDUMINH, LDUMINAH, LDUMINALH, LDUMINLH

Atomic unsigned minimum on halfword in memory atomically loads a 16-bit halfword from memory, compares it against the value held in a register, and stores the smaller value back to memory, treating the values as unsigned numbers. The value initially loaded from memory is returned in the destination register.

- If the destination register is not WZR, LDUMINAH and LDUMINALH load from memory with acquire semantics.
- LDUMINLH and LDUMINALH store to memory with release semantics.
- LDUMINH has neither acquire nor release semantics.

For more information about memory ordering semantics see [Load-Acquire, Store-Release](#).

For information about memory accesses see [Load/Store addressing modes](#).

This instruction is used by the alias [STUMINH, STUMINLH](#).

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	A	R	1	Rs					0	1	1	1	0	0	Rn					Rt				
size											opc																				

### LDUMINAH (A == 1 && R == 0)

LDUMINAH <Ws>, <Wt>, [<Xn|SP>]

### LDUMINALH (A == 1 && R == 1)

LDUMINALH <Ws>, <Wt>, [<Xn|SP>]

### LDUMINH (A == 0 && R == 0)

LDUMINH <Ws>, <Wt>, [<Xn|SP>]

### LDUMINLH (A == 0 && R == 1)

LDUMINLH <Ws>, <Wt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">STUMINH, STUMINLH</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(16) value;
bits(16) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_UMIN, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

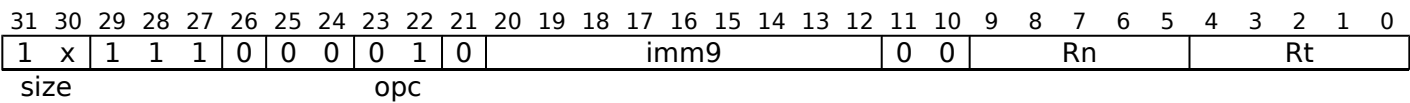
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDUR

Load Register (unscaled) calculates an address from a base register and an immediate offset, loads a 32-bit word or 64-bit doubleword from memory, zero-extends it, and writes it to a register. For information about memory accesses, see [Load/Store addressing modes](#).



## 32-bit (size == 10)

```
LDUR <Wt>, [<Xn|SP>{, #<sim>}]
```

## 64-bit (size == 11)

```
LDUR <Xt>, [<Xn|SP>{, #<sim>}]
```

```
integer scale = UInt(size);
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer regsize;

regsize = if size == '11' then 64 else 32;
integer datasize = 8 << scale;
boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(datasize) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = Mem[address, datasize DIV 8, AccType_NORMAL];
X[t] = ZeroExtend(data, regsize);
```

## Operational information

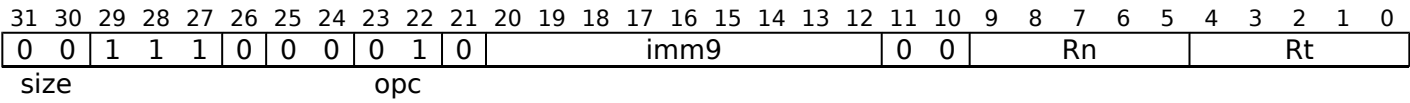
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDURB

Load Register Byte (unscaled) calculates an address from a base register and an immediate offset, loads a byte from memory, zero-extends it, and writes it to a register. For information about memory accesses, see [Load/Store addressing modes](#).



LDURB <Wt>, [<Xn|SP>{, #<simm>}]

bits(64) offset = [SignExtend](#)(imm9, 64);

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <simm> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(8) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

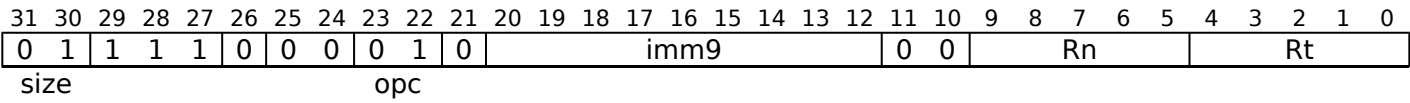
data = Mem[address, 1, AccType\_NORMAL];
X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

# LDURH

Load Register Halfword (unscaled) calculates an address from a base register and an immediate offset, loads a halfword from memory, zero-extends it, and writes it to a register. For information about memory accesses, see [Load/Store addressing modes](#).



```
LDURH <Wt>, [<Xn|SP>{, #<simm>}]

bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <simm> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(16) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = Mem[address, 2, AccType_NORMAL];
X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDURSB

Load Register Signed Byte (unscaled) calculates an address from a base register and an immediate offset, loads a signed byte from memory, sign-extends it, and writes it to a register. For information about memory accesses, see [Load/Store addressing modes](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	1	x	0	imm9									0	0	Rn				Rt					
size									opc																						

## 32-bit (opc == 11)

LDURSB <Wt>, [<Xn|SP>{, #<sim>}]

## 64-bit (opc == 10)

LDURSB <Xt>, [<Xn|SP>{, #<sim>}]

bits(64) offset = [SignExtend](#)(imm9, 64);

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
MemOp memop;
boolean signed;
integer regsize;

if opc<1> == '0' then
    // store or zero-extending load
    memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;
    regsize = 32;
    signed = FALSE;
else
    // sign-extending load
    memop = MemOp_LOAD;
    regsize = if opc<0> == '1' then 32 else 64;
    signed = TRUE;

boolean tag_checked = memop != MemOp_PREFETCH && (n != 31);
```



## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(8) data;

if n == 31 then
    if memop != MemOp_PREFETCH then CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

case memop of
    when MemOp_STORE
        data = X[t];
        Mem[address, 1, AccType_NORMAL] = data;

    when MemOp_LOAD
        data = Mem[address, 1, AccType_NORMAL];
        if signed then
            X[t] = SignExtend(data, regsize);
        else
            X[t] = ZeroExtend(data, regsize);

    when MemOp_PREFETCH
        Prefetch(address, t<4:0>);
```

## Operational information

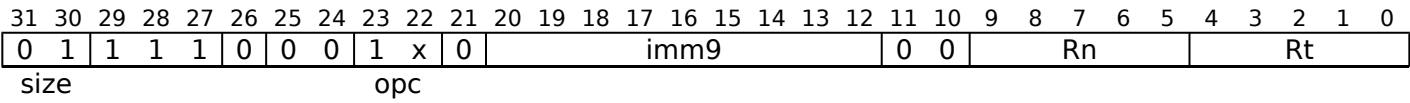
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDURSH

Load Register Signed Halfword (unscaled) calculates an address from a base register and an immediate offset, loads a signed halfword from memory, sign-extends it, and writes it to a register. For information about memory accesses, see [Load/Store addressing modes](#).



## 32-bit (opc == 11)

```
LDURSH <Wt>, [<Xn|SP>{, #<sim>}]
```

## 64-bit (opc == 10)

```
LDURSH <Xt>, [<Xn|SP>{, #<sim>}]
```

```
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
MemOp memop;
boolean signed;
integer regsize;

if opc<1> == '0' then
    // store or zero-extending load
    memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;
    regsize = 32;
    signed = FALSE;
else
    // sign-extending load
    memop = MemOp_LOAD;
    regsize = if opc<0> == '1' then 32 else 64;
    signed = TRUE;

boolean tag_checked = memop != MemOp_PREFETCH && (n != 31);
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(16) data;

if n == 31 then
    if memop != MemOp_PREFETCH then CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

case memop of
    when MemOp_STORE
        data = X[t];
        Mem[address, 2, AccType_NORMAL] = data;

    when MemOp_LOAD
        data = Mem[address, 2, AccType_NORMAL];
        if signed then
            X[t] = SignExtend(data, regsize);
        else
            X[t] = ZeroExtend(data, regsize);

    when MemOp_PREFETCH
        Prefetch(address, t<4:0>);
```

## Operational information

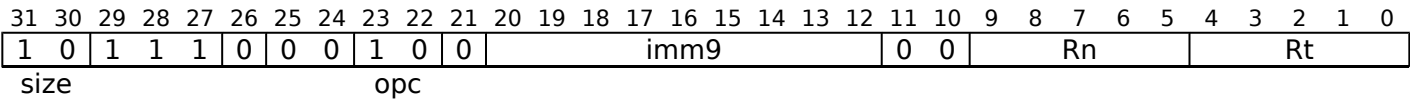
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDURSW

Load Register Signed Word (unscaled) calculates an address from a base register and an immediate offset, loads a signed word from memory, sign-extends it, and writes it to a register. For information about memory accesses, see [Load/Store addressing modes](#).



LDURSW <Xt>, [<Xn|SP>{, #<sim>}]

bits(64) offset = [SignExtend](#)(imm9, 64);

## Assembler Symbols

- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(32) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

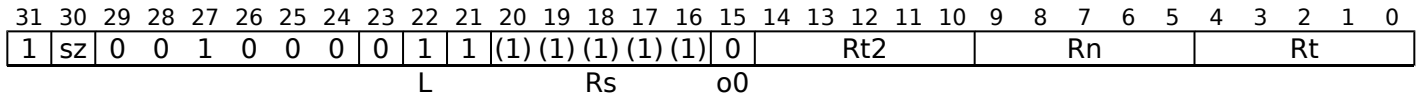
data = Mem[address, 4, AccType\_NORMAL];
X[t] = SignExtend(data, 64);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

## LDXP

Load Exclusive Pair of Registers derives an address from a base register value, loads two 32-bit words or two 64-bit doublewords from memory, and writes them to two registers. For information on single-copy atomicity and alignment requirements, see [Requirements for single-copy atomicity](#) and [Alignment of data accesses](#). The PE marks the physical address being accessed as an exclusive access. This exclusive access mark is checked by Store Exclusive instructions. See [Synchronization and semaphores](#). For information about memory accesses, see [Load/Store addressing modes](#).



### 32-bit (sz == 0)

LDXP <Wt1>, <Wt2>, [<Xn|SP>{, #0}]

### 64-bit (sz == 1)

LDXP <Xt1>, <Xt2>, [<Xn|SP>{, #0}]

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer t2 = UInt(Rt2);

integer elsize = 32 << UInt(sz);
integer datasize = elsize * 2;
boolean tag_checked = n != 31;

boolean rt_unknown = FALSE;
if t == t2 then
    Constraint c = ConstrainUnpredictable(Unpredictable_LDPOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rt_unknown = TRUE;    // result is UNKNOWN
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [LDXP](#).

## Assembler Symbols

- <Wt1>      Is the 32-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
- <Wt2>      Is the 32-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
- <Xt1>      Is the 64-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt2>      Is the 64-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
- <Xn|SP>    Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(datasize) data;
constant integer dbytes = datasize DIV 8;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

// Tell the Exclusives monitors to record a sequence of one or more atomic
// memory reads from virtual address range [address, address+dbytes-1].
// The Exclusives monitor will only be set if all the reads are from the
// same dbytes-aligned physical address, to allow for the possibility of
// an atomicity break if the translation is changed between reads.
AArch64.SetExclusiveMonitors(address, dbytes);

if rt_unknown then
    // ConstrainedUNPREDICTABLE case
    X[t] = bits(datasize) UNKNOWN;    // In this case t = t2
elsif elsize == 32 then
    // 32-bit load exclusive pair (atomic)
    data = Mem[address, dbytes, AccType_ATOMIC];
    if BigEndian(AccType_ATOMIC) then
        X[t] = data<datasize-1:elsize>;
        X[t2] = data<elsize-1:0>;
    else
        X[t] = data<elsize-1:0>;
        X[t2] = data<datasize-1:elsize>;
else // elsize == 64
    // 64-bit load exclusive pair (not atomic),
    // but must be 128-bit aligned
    if address != Align(address, dbytes) then
        AArch64.Abort(address, AlignmentFault(AccType_ATOMIC, FALSE, FALSE));
    X[t] = Mem[address, 8, AccType_ATOMIC];
    X[t2] = Mem[address+8, 8, AccType_ATOMIC];
```

## Operational information

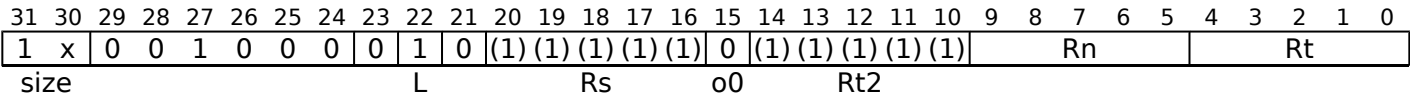
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDXR

Load Exclusive Register derives an address from a base register value, loads a 32-bit word or a 64-bit doubleword from memory, and writes it to a register. The memory access is atomic. The PE marks the physical address being accessed as an exclusive access. This exclusive access mark is checked by Store Exclusive instructions. See [Synchronization and semaphores](#). For information about memory accesses see [Load/Store addressing modes](#).



## 32-bit (size == 10)

```
LDXR <Wt>, [<Xn|SP>{,#0}]
```

## 64-bit (size == 11)

```
LDXR <Xt>, [<Xn|SP>{,#0}]
```

```
integer n = UInt(Rn);
integer t = UInt(Rt);

integer elsize = 8 << UInt(size);
integer regsize = if elsize == 64 then 64 else 32;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(elsize) data;
constant integer dbytes = elsize DIV 8;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

// Tell the Exclusives monitors to record a sequence of one or more atomic
// memory reads from virtual address range [address, address+dbytes-1].
// The Exclusives monitor will only be set if all the reads are from the
// same dbytes-aligned physical address, to allow for the possibility of
// an atomicity break if the translation is changed between reads.
AArch64.SetExclusiveMonitors(address, dbytes);

data = Mem[address, dbytes, AccType_ATOMIC];
X[t] = ZeroExtend(data, regsize);
```

## Operational information

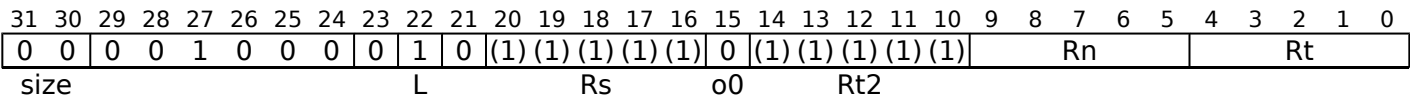
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.





# LDXRB

Load Exclusive Register Byte derives an address from a base register value, loads a byte from memory, zero-extends it and writes it to a register. The memory access is atomic. The PE marks the physical address being accessed as an exclusive access. This exclusive access mark is checked by Store Exclusive instructions. See [Synchronization and semaphores](#). For information about memory accesses see [Load/Store addressing modes](#).



LDXRB <Wt>, [<Xn|SP>{, #0}]

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(8) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

// Tell the Exclusives monitors to record a sequence of one or more atomic
// memory reads from virtual address range [address, address+dbytes-1].
// The Exclusives monitor will only be set if all the reads are from the
// same dbytes-aligned physical address, to allow for the possibility of
// an atomicity break if the translation is changed between reads.
AArch64.SetExclusiveMonitors(address, 1);

data = Mem[address, 1, AccType_ATOMIC];
X[t] = ZeroExtend(data, 32);
```

## Operational information

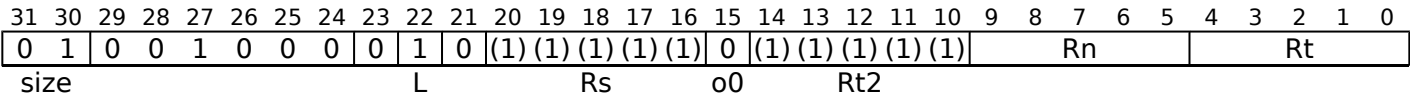
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDXRH

Load Exclusive Register Halfword derives an address from a base register value, loads a halfword from memory, zero-extends it and writes it to a register. The memory access is atomic. The PE marks the physical address being accessed as an exclusive access. This exclusive access mark is checked by Store Exclusive instructions. See [Synchronization and semaphores](#). For information about memory accesses see [Load/Store addressing modes](#).



```
LDXRH <Wt>, [<Xn|SP>{, #0}]

integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(16) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

// Tell the Exclusives monitors to record a sequence of one or more atomic
// memory reads from virtual address range [address, address+dbytes-1].
// The Exclusives monitor will only be set if all the reads are from the
// same dbytes-aligned physical address, to allow for the possibility of
// an atomicity break if the translation is changed between reads.
AArch64.SetExclusiveMonitors(address, 2);

data = Mem[address, 2, AccType_ATOMIC];
X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LSL (register)

Logical Shift Left (register) shifts a register value left by a variable number of bits, shifting in zeros, and writes the result to the destination register. The remainder obtained by dividing the second source register by the data size defines the number of bits by which the first source register is left-shifted.

This is an alias of [LSLV](#). This means:

- The encodings in this description are named to match the encodings of [LSLV](#).
- The description of [LSLV](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	0	1	1	0	1	0	1	1	0	Rm					0	0	1	0	0	0	Rn					Rd				
op2																															

### 32-bit (sf == 0)

LSL <Wd>, <Wn>, <Wm>

is equivalent to

[LSLV](#) <Wd>, <Wn>, <Wm>

and is always the preferred disassembly.

### 64-bit (sf == 1)

LSL <Xd>, <Xn>, <Xm>

is equivalent to

[LSLV](#) <Xd>, <Xn>, <Xm>

and is always the preferred disassembly.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Wm>	Is the 32-bit name of the second general-purpose source register holding a shift amount from 0 to 31 in its bottom 5 bits, encoded in the "Rm" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the second general-purpose source register holding a shift amount from 0 to 63 in its bottom 6 bits, encoded in the "Rm" field.

## Operation

The description of [LSLV](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.



## LSL (immediate)

Logical Shift Left (immediate) shifts a register value left by an immediate number of bits, shifting in zeros, and writes the result to the destination register.

This is an alias of [UBFM](#). This means:

- The encodings in this description are named to match the encodings of [UBFM](#).
- The description of [UBFM](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
sf		1 0		1 0 0		1 1 0		N		immr						!= x11111						Rn						Rd					
opc										imms																							

### 32-bit (sf == 0 && N == 0 && imms != 011111)

LSL <Wd>, <Wn>, #<shift>

is equivalent to

UBFM <Wd>, <Wn>, #(-<shift> MOD 32), #(31-<shift>)

and is the preferred disassembly when `imms + 1 == immr`.

### 64-bit (sf == 1 && N == 1 && imms != 111111)

LSL <Xd>, <Xn>, #<shift>

is equivalent to

UBFM <Xd>, <Xn>, #(-<shift> MOD 64), #(63-<shift>)

and is the preferred disassembly when `imms + 1 == immr`.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
<shift>	For the 32-bit variant: is the shift amount, in the range 0 to 31. For the 64-bit variant: is the shift amount, in the range 0 to 63.

## Operation

The description of [UBFM](#) gives the operational pseudocode for this instruction.

## Operational information

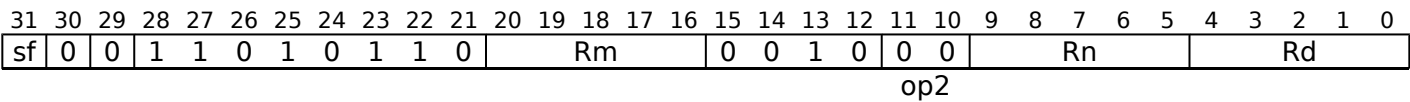
If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

# LSLV

Logical Shift Left Variable shifts a register value left by a variable number of bits, shifting in zeros, and writes the result to the destination register. The remainder obtained by dividing the second source register by the data size defines the number of bits by which the first source register is left-shifted.

This instruction is used by the alias [LSL \(register\)](#).



## 32-bit (sf == 0)

LSLV <Wd>, <Wn>, <Wm>

## 64-bit (sf == 1)

LSLV <Xd>, <Xn>, <Xm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
ShiftType shift_type = DecodeShift(op2);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register holding a shift amount from 0 to 31 in its bottom 5 bits, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register holding a shift amount from 0 to 63 in its bottom 6 bits, encoded in the "Rm" field.

## Operation

```
bits(datasize) result;
bits(datasize) operand2 = X[m];

result = ShiftReg(n, shift_type, UInt(operand2) MOD datasize);
X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LSR (register)

Logical Shift Right (register) shifts a register value right by a variable number of bits, shifting in zeros, and writes the result to the destination register. The remainder obtained by dividing the second source register by the data size defines the number of bits by which the first source register is right-shifted.

This is an alias of [LSRV](#). This means:

- The encodings in this description are named to match the encodings of [LSRV](#).
- The description of [LSRV](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	0	1	1	0	1	0	1	1	0	Rm					0	0	1	0	0	1	Rn					Rd				
op2																															

## 32-bit (sf == 0)

LSR <Wd>, <Wn>, <Wm>

is equivalent to

[LSRV](#) <Wd>, <Wn>, <Wm>

and is always the preferred disassembly.

## 64-bit (sf == 1)

LSR <Xd>, <Xn>, <Xm>

is equivalent to

[LSRV](#) <Xd>, <Xn>, <Xm>

and is always the preferred disassembly.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Wm>	Is the 32-bit name of the second general-purpose source register holding a shift amount from 0 to 31 in its bottom 5 bits, encoded in the "Rm" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the second general-purpose source register holding a shift amount from 0 to 63 in its bottom 6 bits, encoded in the "Rm" field.

## Operation

The description of [LSRV](#) gives the operational pseudocode for this instruction.

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.





## LSR (immediate)

Logical Shift Right (immediate) shifts a register value right by an immediate number of bits, shifting in zeros, and writes the result to the destination register.

This is an alias of [UBFM](#). This means:

- The encodings in this description are named to match the encodings of [UBFM](#).
- The description of [UBFM](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0																		
sf		1		0		1		0		0		1		1		0		N		immr						x		1		1		1		1		1		Rn						Rd					
opc										imms																																							

### 32-bit (sf == 0 && N == 0 && imms == 011111)

LSR <Wd>, <Wn>, #<shift>

is equivalent to

[UBFM](#) <Wd>, <Wn>, #<shift>, #31

and is always the preferred disassembly.

### 64-bit (sf == 1 && N == 1 && imms == 111111)

LSR <Xd>, <Xn>, #<shift>

is equivalent to

[UBFM](#) <Xd>, <Xn>, #<shift>, #63

and is always the preferred disassembly.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
<shift>	For the 32-bit variant: is the shift amount, in the range 0 to 31, encoded in the "immr" field. For the 64-bit variant: is the shift amount, in the range 0 to 63, encoded in the "immr" field.

## Operation

The description of [UBFM](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

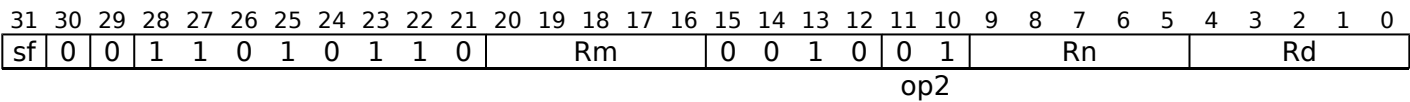
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LSRV

Logical Shift Right Variable shifts a register value right by a variable number of bits, shifting in zeros, and writes the result to the destination register. The remainder obtained by dividing the second source register by the data size defines the number of bits by which the first source register is right-shifted.

This instruction is used by the alias [LSR \(register\)](#).



## 32-bit (sf == 0)

LSRV <Wd>, <Wn>, <Wm>

## 64-bit (sf == 1)

LSRV <Xd>, <Xn>, <Xm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
ShiftType shift_type = DecodeShift(op2);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register holding a shift amount from 0 to 31 in its bottom 5 bits, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register holding a shift amount from 0 to 63 in its bottom 6 bits, encoded in the "Rm" field.

## Operation

```
bits(datasize) result;
bits(datasize) operand2 = X[m];

result = ShiftReg(n, shift_type, UInt(operand2) MOD datasize);
X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

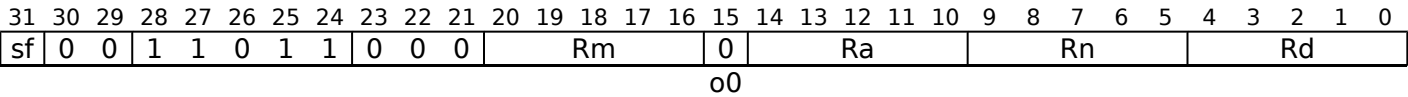
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# MADD

Multiply-Add multiplies two register values, adds a third register value, and writes the result to the destination register.

This instruction is used by the alias [MUL](#).



## 32-bit (sf == 0)

MADD <Wd>, <Wn>, <Wm>, <Wa>

## 64-bit (sf == 1)

MADD <Xd>, <Xn>, <Xm>, <Xa>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer a = UInt(Ra);
integer destsize = if sf == '1' then 64 else 32;
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.
- <Wa> Is the 32-bit name of the third general-purpose source register holding the addend, encoded in the "Ra" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.
- <Xa> Is the 64-bit name of the third general-purpose source register holding the addend, encoded in the "Ra" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">MUL</a>	Ra == '11111'

## Operation

```
bits(destsize) operand1 = X[n];
bits(destsize) operand2 = X[m];
bits(destsize) operand3 = X[a];

integer result;

result = UInt(operand3) + (UInt(operand1) * UInt(operand2));
X[d] = result<destsize-1:0>;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# MNEG

Multiply-Negate multiplies two register values, negates the product, and writes the result to the destination register.

This is an alias of [MSUB](#). This means:

- The encodings in this description are named to match the encodings of [MSUB](#).
- The description of [MSUB](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
sf	0	0	1	1	0	1	1	0	0	0	Rm					1	1	1	1	1	1	Rn					Rd					
o0																Ra																

## 32-bit (sf == 0)

MNEG <Wd>, <Wn>, <Wm>

is equivalent to

[MSUB](#) <Wd>, <Wn>, <Wm>, WZR

and is always the preferred disassembly.

## 64-bit (sf == 1)

MNEG <Xd>, <Xn>, <Xm>

is equivalent to

[MSUB](#) <Xd>, <Xn>, <Xm>, XZR

and is always the preferred disassembly.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
<Wm>	Is the 32-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.

## Operation

The description of [MSUB](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.



# MOV (to/from SP)

Move between register and stack pointer

: Rd = Rn.

This is an alias of [ADD \(immediate\)](#). This means:

- The encodings in this description are named to match the encodings of [ADD \(immediate\)](#).
- The description of [ADD \(immediate\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
sf	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Rn						Rd					
op			S						sh			imm12																					

## 32-bit (sf == 0)

MOV <Wd|WSP>, <Wn|WSP>

is equivalent to

ADD <Wd|WSP>, <Wn|WSP>, #0

and is the preferred disassembly when (Rd == '11111' || Rn == '11111').

## 64-bit (sf == 1)

MOV <Xd|SP>, <Xn|SP>

is equivalent to

ADD <Xd|SP>, <Xn|SP>, #0

and is the preferred disassembly when (Rd == '11111' || Rn == '11111').

## Assembler Symbols

- <Wd|WSP> Is the 32-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Wn|WSP> Is the 32-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.
- <Xd|SP> Is the 64-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Xn|SP> Is the 64-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [ADD \(immediate\)](#) gives the operational pseudocode for this instruction.

## MOV (inverted wide immediate)

Move (inverted wide immediate) moves an inverted 16-bit immediate value to a register.

This is an alias of [MOVN](#). This means:

- The encodings in this description are named to match the encodings of [MOVN](#).
- The description of [MOVN](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf		0 0		1 0 0		1 0 1		hw		imm16																		Rd			
opc																															

### 32-bit (sf == 0 && hw == 0x)

MOV <Wd>, #<imm>

is equivalent to

MOVN <Wd>, #<imm16>, LSL #<shift>

and is the preferred disassembly when `!(IsZero(imm16) && hw != '00') && ! IsOnes(imm16)`.

### 64-bit (sf == 1)

MOV <Xd>, #<imm>

is equivalent to

MOVN <Xd>, #<imm16>, LSL #<shift>

and is the preferred disassembly when `!(IsZero(imm16) && hw != '00')`.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<imm>	For the 32-bit variant: is a 32-bit immediate, the bitwise inverse of which can be encoded in "imm16:hw", but excluding 0xffff0000 and 0x0000ffff  For the 64-bit variant: is a 64-bit immediate, the bitwise inverse of which can be encoded in "imm16:hw".
<shift>	For the 32-bit variant: is the amount by which to shift the immediate left, either 0 (the default) or 16, encoded in the "hw" field as <shift>/16.  For the 64-bit variant: is the amount by which to shift the immediate left, either 0 (the default), 16, 32 or 48, encoded in the "hw" field as <shift>/16.

## Operation

The description of [MOVN](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.





## MOV (wide immediate)

Move (wide immediate) moves a 16-bit immediate value to a register.

This is an alias of [MOVZ](#). This means:

- The encodings in this description are named to match the encodings of [MOVZ](#).
- The description of [MOVZ](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0			
sf		1	0	1		0	0	1	0	1	hw		imm16																		Rd			
opc																																		

### 32-bit (sf == 0 && hw == 0x)

MOV <Wd>, #<imm>

is equivalent to

MOVZ <Wd>, #<imm16>, LSL #<shift>

and is the preferred disassembly when ! (IsZero(imm16) && hw != '00').

### 64-bit (sf == 1)

MOV <Xd>, #<imm>

is equivalent to

MOVZ <Xd>, #<imm16>, LSL #<shift>

and is the preferred disassembly when ! (IsZero(imm16) && hw != '00').

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<imm>	For the 32-bit variant: is a 32-bit immediate which can be encoded in "imm16:hw". For the 64-bit variant: is a 64-bit immediate which can be encoded in "imm16:hw".
<shift>	For the 32-bit variant: is the amount by which to shift the immediate left, either 0 (the default) or 16, encoded in the "hw" field as <shift>/16.  For the 64-bit variant: is the amount by which to shift the immediate left, either 0 (the default), 16, 32 or 48, encoded in the "hw" field as <shift>/16.

## Operation

The description of [MOVZ](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

## MOV (bitmask immediate)

Move (bitmask immediate) writes a bitmask immediate value to a register.

This is an alias of [ORR \(immediate\)](#). This means:

- The encodings in this description are named to match the encodings of [ORR \(immediate\)](#).
- The description of [ORR \(immediate\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
sf	0	1	1	0	0	1	0	0	N	immr						imms						1			1	1	1	1	Rd			
opc										Rn																						

### 32-bit (sf == 0 && N == 0)

MOV <Wd|WSP>, #<imm>

is equivalent to

ORR <Wd|WSP>, WZR, #<imm>

and is the preferred disassembly when ! MoveWidePreferred(sf, N, imms, immr).

### 64-bit (sf == 1)

MOV <Xd|SP>, #<imm>

is equivalent to

ORR <Xd|SP>, XZR, #<imm>

and is the preferred disassembly when ! MoveWidePreferred(sf, N, imms, immr).

## Assembler Symbols

- <Wd|WSP> Is the 32-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Xd|SP> Is the 64-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <imm> For the 32-bit variant: is the bitmask immediate, encoded in "imms:immr", but excluding values which could be encoded by MOVZ or MOVN.  
For the 64-bit variant: is the bitmask immediate, encoded in "N:imms:immr", but excluding values which could be encoded by MOVZ or MOVN.

## Operation

The description of [ORR \(immediate\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# MOV (register)

Move (register) copies the value in a source register to the destination register.

This is an alias of [ORR \(shifted register\)](#). This means:

- The encodings in this description are named to match the encodings of [ORR \(shifted register\)](#).
- The description of [ORR \(shifted register\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	1	0	1	0	1	0	0	0	0	Rm					0	0	0	0	0	0	1	1	1	1	1	Rd				
opc						shift			N								imm6					Rn									

## 32-bit (sf == 0)

MOV <Wd>, <Wm>

is equivalent to

ORR <Wd>, WZR, <Wm>

and is always the preferred disassembly.

## 64-bit (sf == 1)

MOV <Xd>, <Xm>

is equivalent to

ORR <Xd>, XZR, <Xm>

and is always the preferred disassembly.

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wm> Is the 32-bit name of the general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xm> Is the 64-bit name of the general-purpose source register, encoded in the "Rm" field.

## Operation

The description of [ORR \(shifted register\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

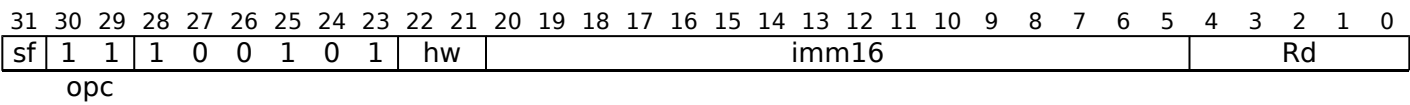
- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# MOVK

Move wide with keep moves an optionally-shifted 16-bit immediate value into a register, keeping other bits unchanged.



## 32-bit (sf == 0 && hw == 0x)

```
MOVK <Wd>, #<imm>{, LSL #<shift>}
```

## 64-bit (sf == 1)

```
MOVK <Xd>, #<imm>{, LSL #<shift>}
```

```
integer d = UInt(Rd);
integer datasize = if sf == '1' then 64 else 32;
integer pos;

if sf == '0' && hw<1> == '1' then UNDEFINED;
pos = UInt(hw:'0000');
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <imm> Is the 16-bit unsigned immediate, in the range 0 to 65535, encoded in the "imm16" field.
- <shift> For the 32-bit variant: is the amount by which to shift the immediate left, either 0 (the default) or 16, encoded in the "hw" field as <shift>/16.  
For the 64-bit variant: is the amount by which to shift the immediate left, either 0 (the default), 16, 32 or 48, encoded in the "hw" field as <shift>/16.

## Operation

```
bits(datasize) result;

result = X[d];
result<pos+15:pos> = imm16;
X[d] = result;
```

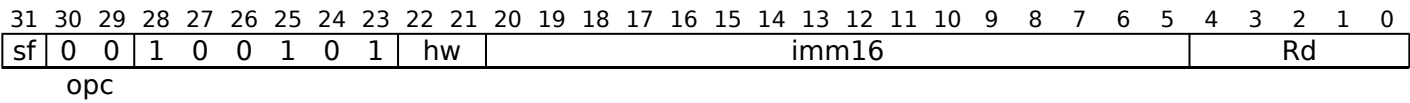
## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# MOVN

Move wide with NOT moves the inverse of an optionally-shifted 16-bit immediate value to a register.

This instruction is used by the alias [MOV \(inverted wide immediate\)](#).



## 32-bit (sf == 0 && hw == 0x)

```
MOVN <Wd>, #<imm>{, LSL #<shift>}
```

## 64-bit (sf == 1)

```
MOVN <Xd>, #<imm>{, LSL #<shift>}
```

```
integer d = UInt(Rd);
integer datasize = if sf == '1' then 64 else 32;
integer pos;

if sf == '0' && hw<1> == '1' then UNDEFINED;
pos = UInt(hw:'0000');
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <imm> Is the 16-bit unsigned immediate, in the range 0 to 65535, encoded in the "imm16" field.
- <shift> For the 32-bit variant: is the amount by which to shift the immediate left, either 0 (the default) or 16, encoded in the "hw" field as <shift>/16.  
For the 64-bit variant: is the amount by which to shift the immediate left, either 0 (the default), 16, 32 or 48, encoded in the "hw" field as <shift>/16.

## Alias Conditions

Alias	Of variant	Is preferred when
<a href="#">MOV (inverted wide immediate)</a>	64-bit	! ( <a href="#">IsZero</a> (imm16) && hw != '00' )
<a href="#">MOV (inverted wide immediate)</a>	32-bit	! ( <a href="#">IsZero</a> (imm16) && hw != '00' ) && ! <a href="#">IsOnes</a> (imm16)

## Operation

```
bits(datasize) result;

result = Zeros();

result<pos+15:pos> = imm16;
result = NOT(result);
X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.

- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

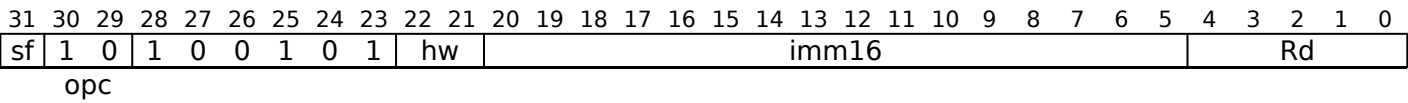
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# MOVZ

Move wide with zero moves an optionally-shifted 16-bit immediate value to a register.

This instruction is used by the alias [MOV \(wide immediate\)](#).



## 32-bit (sf == 0 && hw == 0x)

```
MOVZ <Wd>, #<imm>{, LSL #<shift>}
```

## 64-bit (sf == 1)

```
MOVZ <Xd>, #<imm>{, LSL #<shift>}
```

```
integer d = UInt(Rd);
integer datasize = if sf == '1' then 64 else 32;
integer pos;

if sf == '0' && hw<1> == '1' then UNDEFINED;
pos = UInt(hw:'0000');
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <imm> Is the 16-bit unsigned immediate, in the range 0 to 65535, encoded in the "imm16" field.
- <shift> For the 32-bit variant: is the amount by which to shift the immediate left, either 0 (the default) or 16, encoded in the "hw" field as <shift>/16.  
  
For the 64-bit variant: is the amount by which to shift the immediate left, either 0 (the default), 16, 32 or 48, encoded in the "hw" field as <shift>/16.

## Alias Conditions

Alias	Is preferred when
<a href="#">MOV (wide immediate)</a>	! ( <a href="#">IsZero</a> (imm16) && hw != '00' )

## Operation

```
bits(datasize) result;

result = Zeros();

result<pos+15:pos> = imm16;
X[d] = result;
```

## Operational information

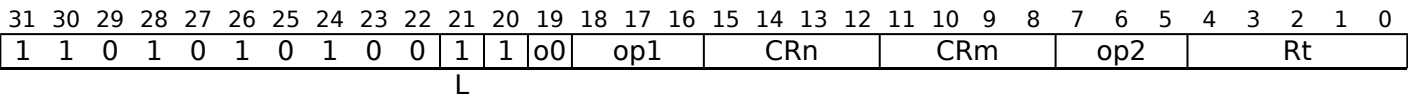
- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.





# MRS

Move System Register allows the PE to read an AArch64 System register into a general-purpose register.



MRS <Xt>, (<systemreg>|S<op0>\_<op1>\_<Cn>\_<Cm>\_<op2>)

```
AArch64.CheckSystemAccess('1':o0, op1, CRn, CRm, op2, Rt, L);

integer t = UInt(Rt);

integer sys_op0 = 2 + UInt(o0);
integer sys_op1 = UInt(op1);
integer sys_op2 = UInt(op2);
integer sys_crn = UInt(CRn);
integer sys_crm = UInt(CRm);
```

## Assembler Symbols

- <Xt> Is the 64-bit name of the general-purpose destination register, encoded in the "Rt" field.
- <systemreg> Is a System register name, encoded in the "o0:op1:CRn:CRm:op2".  
The System register names are defined in 'AArch64 System Registers' in the System Register XML.
- <op0> Is an unsigned immediate, encoded in "o0":

o0	<op0>
0	2
1	3
- <op1> Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the "op1" field.
- <Cn> Is a name 'Cn', with 'n' in the range 0 to 15, encoded in the "CRn" field.
- <Cm> Is a name 'Cm', with 'm' in the range 0 to 15, encoded in the "CRm" field.
- <op2> Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the "op2" field.

## Operation

```
X[t] = AArch64.SysRegRead(sys_op0, sys_op1, sys_crn, sys_crm, sys_op2);
```

## MSR (immediate)

Move immediate value to Special Register moves an immediate value to selected bits of the PSTATE. For more information, see *Process state, PSTATE*.

The bits that can be written by this instruction are:

- PSTATE.D, PSTATE.A, PSTATE.I, PSTATE.F, and PSTATE.SP.
- If *FEAT\_SSBS* is implemented, PSTATE.SSBS.
- If *FEAT\_PAN* is implemented, PSTATE.PAN.
- If *FEAT\_UAO* is implemented, PSTATE.UAO.
- If *FEAT\_DIT* is implemented, PSTATE.DIT.
- If *FEAT\_MTE* is implemented, PSTATE.TCO.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	op1			0	1	0	0	CRm				op2			1	1	1	1	1

MSR <pstatefield>, #<imm>

```
if op1 == '000' && op2 == '000' then SEE "CFINV";
if op1 == '000' && op2 == '001' then SEE "XAFLAG";
if op1 == '000' && op2 == '010' then SEE "AXFLAG";
```

```
AArch64.CheckSystemAccess('00', op1, '0100', CRm, op2, '11111', '0');
bits(2) min_EL;
boolean need_secure = FALSE;
```

```
case op1 of
  when '00x'
    min_EL = EL1;
  when '010'
    min_EL = EL1;
  when '011'
    min_EL = EL0;
  when '100'
    min_EL = EL2;
  when '101'
    if !HaveVirtHostExt() then
      UNDEFINED;
    min_EL = EL2;
  when '110'
    min_EL = EL3;
  when '111'
    min_EL = EL1;
    need_secure = TRUE;
```

```
if UInt(PSTATE.EL) < UInt(min_EL) || (need_secure && !IsSecure()) then
  UNDEFINED;
```

PSTATEField field;

```
case op1:op2 of
  when '000 011'
    if !HaveUA0Ext() then
      UNDEFINED;
    field = PSTATEField_UA0;
  when '000 100'
    if !HavePANExt() then
      UNDEFINED;
    field = PSTATEField_PAN;
  when '000 101' field = PSTATEField_SP;
  when '011 010'
    if !HaveDITExt() then
      UNDEFINED;
    field = PSTATEField_DIT;
  when '011 100'
    if !HaveMTEExt() then
      UNDEFINED;
    field = PSTATEField_TCO;
  when '011 110' field = PSTATEField_DAIFFSet;
  when '011 111' field = PSTATEField_DAIFFClr;
  when '011 001'
    if !HaveSSBSEExt() then
      UNDEFINED;
    field = PSTATEField_SSBS;
  otherwise UNDEFINED;
```

// Check that an AArch64 MSR/MRS access to the DAIF flags is permitted

```
if PSTATE.EL == EL0 && field IN {PSTATEField_DAIFFSet, PSTATEField_DAIFFClr} then
  if !ELUsingAArch32(EL1) && ((EL2Enabled() && HCR_EL2.<E2H,TGE> == '11') || SCTLRL_EL1.UMA == '0') then
    if EL2Enabled() && !ELUsingAArch32(EL2) && HCR_EL2.TGE == '1' then
      AArch64.SystemAccessTrap(EL2, 0x18);
    else
      AArch64.SystemAccessTrap(EL1, 0x18);
```

## Assembler Symbols

<pstatefield> Is a PSTATE field name, encoded in “op1:op2”:

op1	op2	<pstatefield>	Architectural Feature
000	00x	<a href="#">SEE PSTATE</a>	-
000	010	<a href="#">SEE PSTATE</a>	-
000	011	UA0	FEAT_UAO
000	100	PAN	FEAT_PAN
000	101	SPSel	-
000	11x	RESERVED	-
001	xxx	RESERVED	-
010	xxx	RESERVED	-
011	000	RESERVED	-
011	001	SSBS	FEAT_SSBS
011	010	DIT	FEAT_DIT
011	011	RESERVED	-
011	100	TC0	FEAT_MTE
011	101	RESERVED	-
011	110	DAIFSet	-
011	111	DAIFClr	-
1xx	xxx	RESERVED	-

<imm> Is a 4-bit unsigned immediate, in the range 0 to 15, encoded in the "CRm" field.

## Operation

```

case field of
  when PSTATEField\_SSBS
    PSTATE.SSBS = CRm<0>;
  when PSTATEField\_SP
    PSTATE.SP = CRm<0>;
  when PSTATEField\_DAIFSet
    PSTATE.D = PSTATE.D OR CRm<3>;
    PSTATE.A = PSTATE.A OR CRm<2>;
    PSTATE.I = PSTATE.I OR CRm<1>;
    PSTATE.F = PSTATE.F OR CRm<0>;
  when PSTATEField\_DAIFClr
    PSTATE.D = PSTATE.D AND NOT(CRm<3>);
    PSTATE.A = PSTATE.A AND NOT(CRm<2>);
    PSTATE.I = PSTATE.I AND NOT(CRm<1>);
    PSTATE.F = PSTATE.F AND NOT(CRm<0>);
  when PSTATEField\_PAN
    PSTATE.PAN = CRm<0>;
  when PSTATEField\_UAO
    PSTATE.UAO = CRm<0>;
  when PSTATEField\_DIT
    PSTATE.DIT = CRm<0>;
  when PSTATEField\_TC0
    PSTATE.TC0 = CRm<0>;

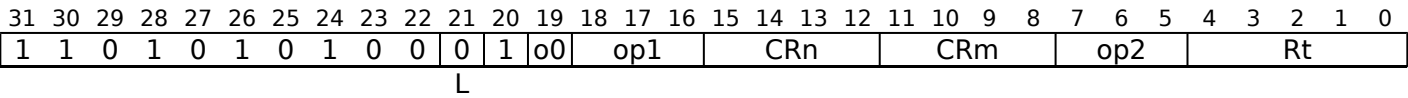
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

MSR (register)

Move general-purpose register to System Register allows the PE to write an AArch64 System register from a general-purpose register.



MSR (<systemreg>|S<op0>\_<op1>\_<Cn>\_<Cm>\_<op2>), <Xt>

```
AArch64.CheckSystemAccess('1':o0, op1, CRn, CRm, op2, Rt, L);

integer t = UInt(Rt);

integer sys_op0 = 2 + UInt(o0);
integer sys_op1 = UInt(op1);
integer sys_op2 = UInt(op2);
integer sys_crn = UInt(CRn);
integer sys_crm = UInt(CRm);
```

Assembler Symbols

- <systemreg> Is a System register name, encoded in the "o0:op1:CRn:CRm:op2".  
The System register names are defined in 'AArch64 System Registers' in the System Register XML.
- <op0> Is an unsigned immediate, encoded in "o0":

o0	<op0>
0	2
1	3
- <op1> Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the "op1" field.
- <Cn> Is a name 'Cn', with 'n' in the range 0 to 15, encoded in the "CRn" field.
- <Cm> Is a name 'Cm', with 'm' in the range 0 to 15, encoded in the "CRm" field.
- <op2> Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the "op2" field.
- <Xt> Is the 64-bit name of the general-purpose source register, encoded in the "Rt" field.

Operation

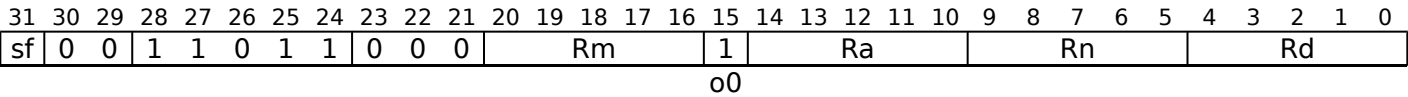
```
AArch64.SysRegWrite(sys_op0, sys_op1, sys_crn, sys_crm, sys_op2, X[t]);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41  
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# MSUB

Multiply-Subtract multiplies two register values, subtracts the product from a third register value, and writes the result to the destination register.

This instruction is used by the alias [MNEG](#).



## 32-bit (sf == 0)

MSUB <Wd>, <Wn>, <Wm>, <Wa>

## 64-bit (sf == 1)

MSUB <Xd>, <Xn>, <Xm>, <Xa>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer a = UInt(Ra);
integer destsize = if sf == '1' then 64 else 32;
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.
- <Wa> Is the 32-bit name of the third general-purpose source register holding the minuend, encoded in the "Ra" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.
- <Xa> Is the 64-bit name of the third general-purpose source register holding the minuend, encoded in the "Ra" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">MNEG</a>	Ra == '11111'

## Operation

```
bits(destsize) operand1 = X[n];
bits(destsize) operand2 = X[m];
bits(destsize) operand3 = X[a];

integer result;

result = UInt(operand3) - (UInt(operand1) * UInt(operand2));
X[d] = result<destsize-1:0>;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# MUL

Multiply

: Rd = Rn \* Rm.

This is an alias of [MADD](#). This means:

- The encodings in this description are named to match the encodings of [MADD](#).
- The description of [MADD](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	0	1	1	0	1	1	0	0	0	Rm				0	1	1	1	1	1	Rn				Rd						
																o0		Ra													

## 32-bit (sf == 0)

MUL <Wd>, <Wn>, <Wm>

is equivalent to

[MADD](#) <Wd>, <Wn>, <Wm>, WZR

and is always the preferred disassembly.

## 64-bit (sf == 1)

MUL <Xd>, <Xn>, <Xm>

is equivalent to

[MADD](#) <Xd>, <Xn>, <Xm>, XZR

and is always the preferred disassembly.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
<Wm>	Is the 32-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.

## Operation

The description of [MADD](#) gives the operational pseudocode for this instruction.

# MVN

Bitwise NOT writes the bitwise inverse of a register value to the destination register.

This is an alias of [ORN \(shifted register\)](#). This means:

- The encodings in this description are named to match the encodings of [ORN \(shifted register\)](#).
- The description of [ORN \(shifted register\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
sf	0	1	0	1	0	1	0	shift	1	Rm						imm6						1	1	1	1	1	Rd					
opc								N								Rn																

## 32-bit (sf == 0)

MVN <Wd>, <Wm>{, <shift> #<amount>}

is equivalent to

ORN <Wd>, WZR, <Wm>{, <shift> #<amount>}

and is always the preferred disassembly.

## 64-bit (sf == 1)

MVN <Xd>, <Xm>{, <shift> #<amount>}

is equivalent to

ORN <Xd>, XZR, <Xm>{, <shift> #<amount>}

and is always the preferred disassembly.

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wm> Is the 32-bit name of the general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xm> Is the 64-bit name of the general-purpose source register, encoded in the "Rm" field.
- <shift> Is the optional shift to be applied to the final source, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	ROR

- <amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.
- For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field,

## Operation

The description of [ORN \(shifted register\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# NEG (shifted register)

Negate (shifted register) negates an optionally-shifted register value, and writes the result to the destination register.

This is an alias of [SUB \(shifted register\)](#). This means:

- The encodings in this description are named to match the encodings of [SUB \(shifted register\)](#).
- The description of [SUB \(shifted register\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
sf	1	0	0	1	0	1	1	shift	0	Rm						imm6						1	1	1	1	1	Rd					
op S										Rn																						

## 32-bit (sf == 0)

NEG <Wd>, <Wm>{, <shift> #<amount>}

is equivalent to

SUB <Wd>, WZR, <Wm> {, <shift> #<amount>}

and is always the preferred disassembly.

## 64-bit (sf == 1)

NEG <Xd>, <Xm>{, <shift> #<amount>}

is equivalent to

SUB <Xd>, XZR, <Xm> {, <shift> #<amount>}

and is always the preferred disassembly.

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wm> Is the 32-bit name of the general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xm> Is the 64-bit name of the general-purpose source register, encoded in the "Rm" field.
- <shift> Is the optional shift type to be applied to the second source operand, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	RESERVED

- <amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.
- For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field.

## Operation

The description of [SUB \(shifted register\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

NEGS

Negate, setting flags, negates an optionally-shifted register value, and writes the result to the destination register. It updates the condition flags based on the result.

This is an alias of [SUBS \(shifted register\)](#). This means:

- The encodings in this description are named to match the encodings of [SUBS \(shifted register\)](#).
- The description of [SUBS \(shifted register\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
sf	1	1	0	1	0	1	1	shift	0	Rm						imm6						1	1	1	1	1	!= 11111					
op				S																Rn						Rd						

32-bit (sf == 0)

NEGS <Wd>, <Wm>{, <shift> #<amount>}

is equivalent to

[SUBS](#) <Wd>, WZR, <Wm> {, <shift> #<amount>}

and is always the preferred disassembly.

64-bit (sf == 1)

NEGS <Xd>, <Xm>{, <shift> #<amount>}

is equivalent to

[SUBS](#) <Xd>, XZR, <Xm> {, <shift> #<amount>}

and is always the preferred disassembly.

Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wm> Is the 32-bit name of the general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xm> Is the 64-bit name of the general-purpose source register, encoded in the "Rm" field.
- <shift> Is the optional shift type to be applied to the second source operand, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	RESERVED

- <amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.  
For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field.

Operation

The description of [SUBS \(shifted register\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# NGC

Negate with Carry negates the sum of a register value and the value of NOT (Carry flag), and writes the result to the destination register.

This is an alias of [SBC](#). This means:

- The encodings in this description are named to match the encodings of [SBC](#).
- The description of [SBC](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	1	0	1	1	0	1	0	0	0	0	Rm					0	0	0	0	0	0	1	1	1	1	1	Rd				
op S											Rn																				

## 32-bit (sf == 0)

NGC <Wd>, <Wm>

is equivalent to

[SBC](#) <Wd>, WZR, <Wm>

and is always the preferred disassembly.

## 64-bit (sf == 1)

NGC <Xd>, <Xm>

is equivalent to

[SBC](#) <Xd>, XZR, <Xm>

and is always the preferred disassembly.

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wm> Is the 32-bit name of the general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xm> Is the 64-bit name of the general-purpose source register, encoded in the "Rm" field.

## Operation

The description of [SBC](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# NGCS

Negate with Carry, setting flags, negates the sum of a register value and the value of NOT (Carry flag), and writes the result to the destination register. It updates the condition flags based on the result.

This is an alias of [SBCS](#). This means:

- The encodings in this description are named to match the encodings of [SBCS](#).
- The description of [SBCS](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	1	1	1	1	0	1	0	0	0	0	Rm					0	0	0	0	0	0	1	1	1	1	1	Rd				
op S											Rn																				

## 32-bit (sf == 0)

NGCS <Wd>, <Wm>

is equivalent to

[SBCS](#) <Wd>, WZR, <Wm>

and is always the preferred disassembly.

## 64-bit (sf == 1)

NGCS <Xd>, <Xm>

is equivalent to

[SBCS](#) <Xd>, XZR, <Xm>

and is always the preferred disassembly.

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wm> Is the 32-bit name of the general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xm> Is the 64-bit name of the general-purpose source register, encoded in the "Rm" field.

## Operation

The description of [SBCS](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# NOP

No Operation does nothing, other than advance the value of the program counter by 4. This instruction can be used for instruction alignment purposes.

The timing effects of including a NOP instruction in a program are not guaranteed. It can increase execution time, leave it unchanged, or even reduce it. Therefore, NOP instructions are not suitable for timing loops.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	1	1	1	1	1			
																				CRm				op2											

## NOP

```
// Empty.
```

## Operation

```
// do nothing
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

## ORN (shifted register)

Bitwise OR NOT (shifted register) performs a bitwise (inclusive) OR of a register value and the complement of an optionally-shifted register value, and writes the result to the destination register.

This instruction is used by the alias [MVN](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	1	0	1	0	1	0	shift	1	Rm						imm6						Rn						Rd			
opc								N																							

### 32-bit (sf == 0)

ORN <Wd>, <Wn>, <Wm>{, <shift> #<amount>}

### 64-bit (sf == 1)

ORN <Xd>, <Xn>, <Xm>{, <shift> #<amount>}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
if sf == '0' && imm6<5> == '1' then UNDEFINED;

ShiftType shift_type = DecodeShift(shift);
integer shift_amount = UInt(imm6);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <shift> Is the optional shift to be applied to the final source, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	ROR
- <amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.  
For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field,

## Alias Conditions

Alias	Is preferred when
<a href="#">MVN</a>	Rn == '11111'

## Operation

```
bits(datasize) operand1 = X[n];  
bits(datasize) operand2 = ShiftReg(m, shift_type, shift_amount);  
  
operand2 = NOT(operand2);  
  
result = operand1 OR operand2;  
X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

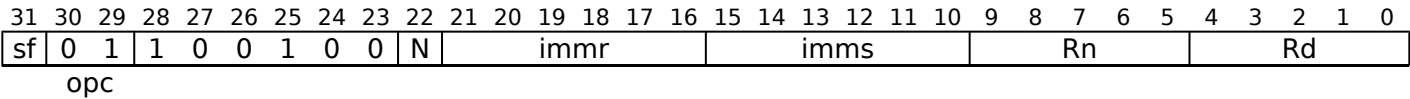
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# ORR (immediate)

Bitwise OR (immediate) performs a bitwise (inclusive) OR of a register value and an immediate register value, and writes the result to the destination register.

This instruction is used by the alias [MOV \(bitmask immediate\)](#).



## 32-bit (sf == 0 && N == 0)

ORR <Wd|WSP>, <Wn>, #<imm>

## 64-bit (sf == 1)

ORR <Xd|SP>, <Xn>, #<imm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer datasize = if sf == '1' then 64 else 32;
bits(datasize) imm;
if sf == '0' && N != '0' then UNDEFINED;
(imm, -) = DecodeBitMasks(N, imms, immr, TRUE);
```

## Assembler Symbols

<Wd WSP>	Is the 32-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
<Xd SP>	Is the 64-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
<imm>	For the 32-bit variant: is the bitmask immediate, encoded in "imms:immr". For the 64-bit variant: is the bitmask immediate, encoded in "N:imms:immr".

## Alias Conditions

Alias	Is preferred when
<a href="#">MOV (bitmask immediate)</a>	Rn == '11111' && ! <a href="#">MoveWidePreferred</a> (sf, N, imms, immr)

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = X[n];

result = operand1 OR imm;
if d == 31 then
    SP[] = result;
else
    X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.

- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# ORR (shifted register)

Bitwise OR (shifted register) performs a bitwise (inclusive) OR of a register value and an optionally-shifted register value, and writes the result to the destination register.

This instruction is used by the alias [MOV \(register\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	1	0	1	0	1	0	shift	0	Rm						imm6						Rn						Rd			
opc								N																							

## 32-bit (sf == 0)

ORR <Wd>, <Wn>, <Wm>{, <shift> #<amount>}

## 64-bit (sf == 1)

ORR <Xd>, <Xn>, <Xm>{, <shift> #<amount>}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
if sf == '0' && imm6<5> == '1' then UNDEFINED;

ShiftType shift_type = DecodeShift(shift);
integer shift_amount = UInt(imm6);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.

<shift> Is the optional shift to be applied to the final source, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	ROR

<amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.  
For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field,

## Alias Conditions

Alias	Is preferred when
<a href="#">MOV (register)</a>	shift == '00' && imm6 == '000000' && Rn == '11111'

## Operation

```
bits(datasize) operand1 = X[n];  
bits(datasize) operand2 = ShiftReg(m, shift_type, shift_amount);  
  
result = operand1 OR operand2;  
X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



PACDA, PACDZA

Pointer Authentication Code for Data address, using key A. This instruction computes and inserts a pointer authentication code for a data address, using a modifier and key A.

The address is in the general-purpose register that is specified by <Xd>.

The modifier is:

- In the general-purpose register or stack pointer that is specified by <Xn|SP> for PACDA.
- The value zero, for PACDZA.

Integer  
(FEAT\_PAuth)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	1	0	1	1	0	0	0	0	0	1	0	0	Z	0	1	0	Rn					Rd				

PACDA (Z == 0)

PACDA <Xd>, <Xn|SP>

PACDZA (Z == 1 && Rn == 11111)

PACDZA <Xd>

```
boolean source_is_sp = FALSE;
integer d = UInt(Rd);
integer n = UInt(Rn);

if !HavePACExt() then
    UNDEFINED;

if Z == '0' then // PACDA
    if n == 31 then source_is_sp = TRUE;
else // PACDZA
    if n != 31 then UNDEFINED;
```

Assembler Symbols

<Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.

<Xn|SP> Is the 64-bit name of the general-purpose source register or stack pointer, encoded in the "Rn" field.

Operation

```
if source_is_sp then
    X[d] = AddPACDA(X[d], SP[]);
else
    X[d] = AddPACDA(X[d], X[n]);
```

# PACDB, PACDZB

Pointer Authentication Code for Data address, using key B. This instruction computes and inserts a pointer authentication code for a data address, using a modifier and key B.

The address is in the general-purpose register that is specified by <Xd>.

The modifier is:

- In the general-purpose register or stack pointer that is specified by <Xn|SP> for PACDB.
- The value zero, for PACDZB.

## Integer (FEAT\_PAuth)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	1	0	1	1	0	0	0	0	0	1	0	0	Z	0	1	1	Rn				Rd					

### PACDB (Z == 0)

PACDB <Xd>, <Xn|SP>

### PACDZB (Z == 1 && Rn == 11111)

PACDZB <Xd>

```
boolean source_is_sp = FALSE;
integer d = UInt(Rd);
integer n = UInt(Rn);

if !HavePACExt() then
    UNDEFINED;

if Z == '0' then // PACDB
    if n == 31 then source_is_sp = TRUE;
else // PACDZB
    if n != 31 then UNDEFINED;
```

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn|SP> Is the 64-bit name of the general-purpose source register or stack pointer, encoded in the "Rn" field.

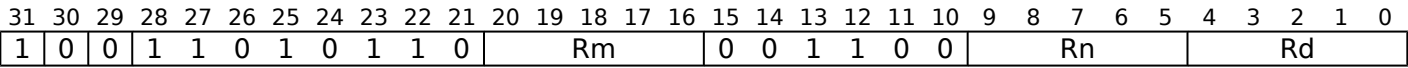
## Operation

```
if source_is_sp then
    X[d] = AddPACDB(X[d], SP[]);
else
    X[d] = AddPACDB(X[d], X[n]);
```

# PACGA

Pointer Authentication Code, using Generic key. This instruction computes the pointer authentication code for an address in the first source register, using a modifier in the second source register, and the Generic key. The computed pointer authentication code is returned in the upper 32 bits of the destination register.

## Integer (FEAT\_PAuth)



PACGA <Xd>, <Xn>, <Xm|SP>

```
boolean source_is_sp = FALSE;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if !HavePACExt() then
    UNDEFINED;

if m == 31 then source_is_sp = TRUE;
```

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm|SP> Is the 64-bit name of the second general-purpose source register or stack pointer, encoded in the "Rm" field.

## Operation

```
if source_is_sp then
    X[d] = AddPACGA(X[n], SP[]);
else
    X[d] = AddPACGA(X[n], X[m]);
```

PACIA, PACIA1716, PACIASP, PACIAZ, PACIZA

Pointer Authentication Code for Instruction address, using key A. This instruction computes and inserts a pointer authentication code for an instruction address, using a modifier and key A.

The address is:

- In the general-purpose register that is specified by <Xd> for PACIA and PACIZA.
- In X17, for PACIA1716.
- In X30, for PACIASP and PACIAZ.

The modifier is:

- In the general-purpose register or stack pointer that is specified by <Xn|SP> for PACIA.
- The value zero, for PACIZA and PACIAZ.
- In X16, for PACIA1716.
- In SP, for PACIASP.

It has encodings from 2 classes: [Integer](#) and [System](#)

Integer

(FEAT\_PAuth)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	1	0	1	1	0	0	0	0	0	1	0	0	Z	0	0	0	Rn				Rd					

PACIA (Z == 0)

PACIA <Xd>, <Xn|SP>

PACIZA (Z == 1 && Rn == 11111)

PACIZA <Xd>

```
boolean source_is_sp = FALSE;
integer d = UInt(Rd);
integer n = UInt(Rn);

if !HavePACExt() then
    UNDEFINED;

if Z == '0' then // PACIA
    if n == 31 then source_is_sp = TRUE;
else // PACIZA
    if n != 31 then UNDEFINED;
```

System

(FEAT\_PAuth)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0					
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	x	1	0	0	x	1	1	1	1	1					
																					CRm				op2											

## PACIA1716 (CRm == 0001 && op2 == 000)

PACIA1716

## PACIASP (CRm == 0011 && op2 == 001)

PACIASP

## PACIAZ (CRm == 0011 && op2 == 000)

PACIAZ

```
integer d;  
integer n;  
boolean source_is_sp = FALSE;  
  
case CRm:op2 of  
  when '0011 000'    // PACIAZ  
    d = 30;  
    n = 31;  
  when '0011 001'    // PACIASP  
    d = 30;  
    source_is_sp = TRUE;  
    if HaveBTIExt() then  
      // Check for branch target compatibility between PSTATE.BTYPE  
      // and implicit branch target of PACIASP instruction.  
      SetBTypeCompatible(BTypeCompatible_PACIXSP());  
  
  when '0001 000'    // PACIA1716  
    d = 17;  
    n = 16;  
  when '0001 010' SEE "PACIB";  
  when '0001 100' SEE "AUTIA";  
  when '0001 110' SEE "AUTIB";  
  when '0011 01x' SEE "PACIB";  
  when '0011 10x' SEE "AUTIA";  
  when '0011 11x' SEE "AUTIB";  
  when '0000 111' SEE "XPACLRI";  
  otherwise SEE "HINT";
```

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn|SP> Is the 64-bit name of the general-purpose source register or stack pointer, encoded in the "Rn" field.

## Operation

```
if HavePACExt() then  
  if source_is_sp then  
    X[d] = AddPACIA(X[d], SP[]);  
  else  
    X[d] = AddPACIA(X[d], X[n]);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

PACIB, PACIB1716, PACIBSP, PACIBZ, PACIZB

Pointer Authentication Code for Instruction address, using key B. This instruction computes and inserts a pointer authentication code for an instruction address, using a modifier and key B.

The address is:

- In the general-purpose register that is specified by <Xd> for PACIB and PACIZB.
- In X17, for PACIB1716.
- In X30, for PACIBSP and PACIBZ.

The modifier is:

- In the general-purpose register or stack pointer that is specified by <Xn|SP> for PACIB.
- The value zero, for PACIZB and PACIBZ.
- In X16, for PACIB1716.
- In SP, for PACIBSP.

It has encodings from 2 classes: [Integer](#) and [System](#)

Integer

(FEAT\_PAuth)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	1	0	1	1	0	0	0	0	0	1	0	0	Z	0	0	1	Rn				Rd					

PACIB (Z == 0)

PACIB <Xd>, <Xn|SP>

PACIZB (Z == 1 && Rn == 11111)

PACIZB <Xd>

```
boolean source_is_sp = FALSE;
integer d = UInt(Rd);
integer n = UInt(Rn);

if !HavePACExt() then
    UNDEFINED;

if Z == '0' then // PACIB
    if n == 31 then source_is_sp = TRUE;
else // PACIZB
    if n != 31 then UNDEFINED;
```

System

(FEAT\_PAuth)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0					
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	x	1	0	1	x	1	1	1	1	1					
																					CRm				op2											

## PACIB1716 (CRm == 0001 && op2 == 010)

PACIB1716

## PACIBSP (CRm == 0011 && op2 == 011)

PACIBSP

## PACIBZ (CRm == 0011 && op2 == 010)

PACIBZ

```
integer d;  
integer n;  
boolean source_is_sp = FALSE;  
  
case CRm:op2 of  
  when '0011 010'    // PACIBZ  
    d = 30;  
    n = 31;  
  when '0011 011'    // PACIBSP  
    d = 30;  
    source_is_sp = TRUE;  
    if HaveBTIExt() then  
      // Check for branch target compatibility between PSTATE.BTYPE  
      // and implicit branch target of PACIBSP instruction.  
      SetBTypeCompatible(BTypeCompatible_PACIXSP());  
  when '0001 010'    // PACIB1716  
    d = 17;  
    n = 16;  
  when '0001 000' SEE "PACIA";  
  when '0001 100' SEE "AUTIA";  
  when '0001 110' SEE "AUTIB";  
  when '0011 00x' SEE "PACIA";  
  when '0011 10x' SEE "AUTIA";  
  when '0011 11x' SEE "AUTIB";  
  when '0000 111' SEE "XPACLR1";  
  otherwise SEE "HINT";
```

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn|SP> Is the 64-bit name of the general-purpose source register or stack pointer, encoded in the "Rn" field.

## Operation

```
if HavePACExt() then  
  if source_is_sp then  
    X[d] = AddPACIB(X[d], SP[]);  
  else  
    X[d] = AddPACIB(X[d], X[n]);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## PRFM (immediate)

Prefetch Memory (immediate) signals the memory system that data memory accesses from a specified address are likely to occur in the near future. The memory system can respond by taking actions that are expected to speed up the memory accesses when they do occur, such as preloading the cache line containing the specified address into one or more caches.

The effect of an PRFM instruction is IMPLEMENTATION DEFINED. For more information, see [Prefetch memory](#).

For information about memory accesses, see [Load/Store addressing modes](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	1	1	0	0	1	1	0	imm12												Rn				Rt					
size										opc																					

PRFM (<prfop>|<#imm5>), [<Xn|SP>{, #<pimm>}]

bits(64) offset = LSL(ZeroExtend(imm12, 64), 3);

### Assembler Symbols

- <prfop> Is the prefetch operation, defined as <type><target><policy>.  
<type> is one of:
- PLD**  
Prefetch for load, encoded in the "Rt<4:3>" field as 0b00.
  - PLI**  
Preload instructions, encoded in the "Rt<4:3>" field as 0b01.
  - PST**  
Prefetch for store, encoded in the "Rt<4:3>" field as 0b10.
- <target> is one of:
- L1**  
Level 1 cache, encoded in the "Rt<2:1>" field as 0b00.
  - L2**  
Level 2 cache, encoded in the "Rt<2:1>" field as 0b01.
  - L3**  
Level 3 cache, encoded in the "Rt<2:1>" field as 0b10.
- <policy> is one of:
- KEEP**  
Retained or temporal prefetch, allocated in the cache normally. Encoded in the "Rt<0>" field as 0.
  - STRM**  
Streaming or non-temporal prefetch, for data that is used only once. Encoded in the "Rt<0>" field as 1.
- For more information on these prefetch operations, see [Prefetch memory](#).  
For other encodings of the "Rt" field, use <imm5>.
- <imm5> Is the prefetch operation encoding as an immediate, in the range 0 to 31, encoded in the "Rt" field.  
This syntax is only for encodings that are not accessible using <prfop>.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <pimm> Is the optional positive immediate byte offset, a multiple of 8 in the range 0 to 32760, defaulting to 0 and encoded in the "imm12" field as <pimm>/8.

### Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
```



## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(FALSE);

bits(64) address;

if n == 31 then
    address = SP[];
else
    address = X[n];

address = address + offset;

Prefetch(address, t<4:0>);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

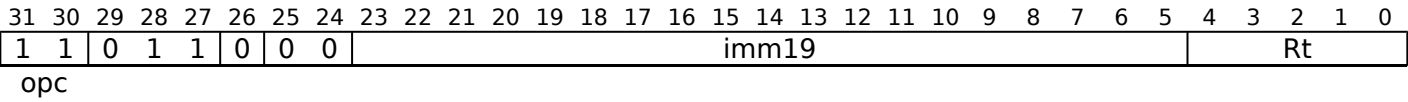
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## PRFM (literal)

Prefetch Memory (literal) signals the memory system that data memory accesses from a specified address are likely to occur in the near future. The memory system can respond by taking actions that are expected to speed up the memory accesses when they do occur, such as preloading the cache line containing the specified address into one or more caches.

The effect of an PRFM instruction is IMPLEMENTATION DEFINED. For more information, see *Prefetch memory*.

For information about memory accesses, see *Load/Store addressing modes*.



PRFM (<prfop>|<imm5>), <label>

```
integer t = UInt(Rt);
bits(64) offset;

offset = SignExtend(imm19:'00', 64);
```

### Assembler Symbols

- <prfop>

Is the prefetch operation, defined as <type><target><policy>.  
<type> is one of:  
**PLD**  
Prefetch for load, encoded in the "Rt<4:3>" field as 0b00.  
**PLI**  
Preload instructions, encoded in the "Rt<4:3>" field as 0b01.  
**PST**  
Prefetch for store, encoded in the "Rt<4:3>" field as 0b10.  
<target> is one of:  
**L1**  
Level 1 cache, encoded in the "Rt<2:1>" field as 0b00.  
**L2**  
Level 2 cache, encoded in the "Rt<2:1>" field as 0b01.  
**L3**  
Level 3 cache, encoded in the "Rt<2:1>" field as 0b10.  
<policy> is one of:  
**KEEP**  
Retained or temporal prefetch, allocated in the cache normally. Encoded in the "Rt<0>" field as 0.  
**STRM**  
Streaming or non-temporal prefetch, for data that is used only once. Encoded in the "Rt<0>" field as 1.  
  
For more information on these prefetch operations, see *Prefetch memory*.  
For other encodings of the "Rt" field, use <imm5>.
- <imm5>

Is the prefetch operation encoding as an immediate, in the range 0 to 31, encoded in the "Rt" field.  
This syntax is only for encodings that are not accessible using <prfop>.
- <label>

Is the program label from which the data is to be loaded. Its offset from the address of this instruction, in the range +/-1MB, is encoded as "imm19" times 4.

## Operation

```
bits(64) address = PC[] + offset;  
if HaveMTE2Ext() then  
    SetTagCheckedInstruction(FALSE);  
Prefetch(address, t<4:0>);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## PRFM (register)

Prefetch Memory (register) signals the memory system that data memory accesses from a specified address are likely to occur in the near future. The memory system can respond by taking actions that are expected to speed up the memory accesses when they do occur, such as preloading the cache line containing the specified address into one or more caches.

The effect of an PRFM instruction is IMPLEMENTATION DEFINED. For more information, see [Prefetch memory](#).

For information about memory accesses, see [Load/Store addressing modes](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	1	1	0	0	0	1	0	1	Rm				option		S	1	0	Rn				Rt							
size								opc																							

PRFM (<prfop>|<imm5>), [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]

```
if option<1> == '0' then UNDEFINED;    // sub-word index
ExtendType extend_type = DecodeRegExtend(option);
integer shift = if S == '1' then 3 else 0;
```

### Assembler Symbols

- <prfop>

Is the prefetch operation, defined as <type><target><policy>. <type> is one of:  
**PLD**  
Prefetch for load, encoded in the "Rt<4:3>" field as 0b00.  
**PLI**  
Preload instructions, encoded in the "Rt<4:3>" field as 0b01.  
**PST**  
Prefetch for store, encoded in the "Rt<4:3>" field as 0b10.  
<target> is one of:  
**L1**  
Level 1 cache, encoded in the "Rt<2:1>" field as 0b00.  
**L2**  
Level 2 cache, encoded in the "Rt<2:1>" field as 0b01.  
**L3**  
Level 3 cache, encoded in the "Rt<2:1>" field as 0b10.  
<policy> is one of:  
**KEEP**  
Retained or temporal prefetch, allocated in the cache normally. Encoded in the "Rt<0>" field as 0.  
**STRM**  
Streaming or non-temporal prefetch, for data that is used only once. Encoded in the "Rt<0>" field as 1.  
  
For more information on these prefetch operations, see [Prefetch memory](#).  
For other encodings of the "Rt" field, use <imm5>.
- <imm5>

Is the prefetch operation encoding as an immediate, in the range 0 to 31, encoded in the "Rt" field. This syntax is only for encodings that are not accessible using <prfop>.
- <Xn|SP>

Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Wm>

When option<0> is set to 0, is the 32-bit name of the general-purpose index register, encoded in the "Rm" field.
- <Xm>

When option<0> is set to 1, is the 64-bit name of the general-purpose index register, encoded in the "Rm" field.

<extend> Is the index extend/shift specifier, defaulting to LSL, and which must be omitted for the LSL option when <amount> is omitted. encoded in “option”:

option	<extend>
010	UXTW
011	LSL
110	SXTW
111	SCTX

<amount> Is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in “S”:

S	<amount>
0	#0
1	#3

Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer m = UInt(Rm);
```

Operation

```
bits(64) offset = ExtendReg(m, extend_type, shift);
if HaveMTE2Ext() then
    SetTagCheckedInstruction(FALSE);

bits(64) address;

if n == 31 then
    address = SP[];
else
    address = X[n];

address = address + offset;
Prefetch(address, t<4:0>);
```

# PRFUM

Prefetch Memory (unscaled offset) signals the memory system that data memory accesses from a specified address are likely to occur in the near future. The memory system can respond by taking actions that are expected to speed up the memory accesses when they do occur, such as preloading the cache line containing the specified address into one or more caches.

The effect of an PRFUM instruction is IMPLEMENTATION DEFINED. For more information, see [Prefetch memory](#).

For information about memory accesses, see [Load/Store addressing modes](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	1	1	0	0	0	1	0	0	imm9									0	0	Rn				Rt					
size										opc																					

PRFUM (<prfop>|<imm5>), [<Xn|SP>{, #<sim>}]

bits(64) offset = [SignExtend](#)(imm9, 64);

## Assembler Symbols

- <prfop> Is the prefetch operation, defined as <type><target><policy>.  
<type> is one of:  
**PLD**  
Prefetch for load, encoded in the "Rt<4:3>" field as 0b00.  
**PLI**  
Preload instructions, encoded in the "Rt<4:3>" field as 0b01.  
**PST**  
Prefetch for store, encoded in the "Rt<4:3>" field as 0b10.  
<target> is one of:  
**L1**  
Level 1 cache, encoded in the "Rt<2:1>" field as 0b00.  
**L2**  
Level 2 cache, encoded in the "Rt<2:1>" field as 0b01.  
**L3**  
Level 3 cache, encoded in the "Rt<2:1>" field as 0b10.  
<policy> is one of:  
**KEEP**  
Retained or temporal prefetch, allocated in the cache normally. Encoded in the "Rt<0>" field as 0.  
**STRM**  
Streaming or non-temporal prefetch, for data that is used only once. Encoded in the "Rt<0>" field as 1.  
  
For more information on these prefetch operations, see [Prefetch memory](#).  
For other encodings of the "Rt" field, use <imm5>.
- <imm5> Is the prefetch operation encoding as an immediate, in the range 0 to 31, encoded in the "Rt" field.  
This syntax is only for encodings that are not accessible using <prfop>.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(FALSE);

bits(64) address;

if n == 31 then
    address = SP[];
else
    address = X[n];

address = address + offset;

Prefetch(address, t<4:0>);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

PSB CSYNC

Profiling Synchronization Barrier. This instruction is a barrier that ensures that all existing profiling data for the current PE has been formatted, and profiling buffer addresses have been translated such that all writes to the profiling buffer have been initiated. A following DSB instruction completes when the writes to the profiling buffer have completed.

If the Statistical Profiling Extension is not implemented, this instruction executes as a NOP.

System  
(FEAT\_SPE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0			
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	1	0	0	0	1	1	1	1	1	1			
																				CRm				op2										

PSB CSYNC

```
if !HaveStatisticalProfiling() then EndOfInstruction();
```

Operation

```
ProfilingSynchronizationBarrier();
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



PSSBB

Physical Speculative Store Bypass Barrier is a memory barrier which prevents speculative loads from bypassing earlier stores to the same physical address.

The semantics of the Physical Speculative Store Bypass Barrier are:

- When a load to a location appears in program order after the PSSBB, then the load does not speculatively read an entry earlier in the coherence order for that location than the entry generated by the latest store satisfying all of the following conditions:
  - The store is to the same location as the load.
  - The store appears in program order before the PSSBB.
- When a load to a location appears in program order before the PSSBB, then the load does not speculatively read data from any store satisfying all of the following conditions:
  - The store is to the same location as the load.
  - The store appears in program order after the PSSBB.

This is an alias of [DSB](#). This means:

- The encodings in this description are named to match the encodings of [DSB](#).
- The description of [DSB](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	1	0	1	0	0	1	0	0	1	1	1	1	1
																CRm				opc											

PSSBB

is equivalent to

[DSB](#) #4

and is always the preferred disassembly.

Operation

The description of [DSB](#) gives the operational pseudocode for this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# RBIT

Reverse Bits reverses the bit order in a register.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
sf	1	0	1	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	Rn						Rd					

## 32-bit (sf == 0)

RBIT <Wd>, <Wn>

## 64-bit (sf == 1)

RBIT <Xd>, <Xn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer datasize = if sf == '1' then 64 else 32;
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.

## Operation

```
bits(datasize) operand = X[n];
bits(datasize) result;

for i = 0 to datasize-1
    result<datasize-1-i> = operand<i>;

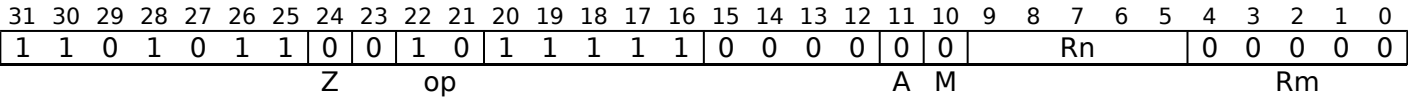
X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# RET

Return from subroutine branches unconditionally to an address in a register, with a hint that this is a subroutine return.



RET {<Xn>}

```
integer n = UInt(Rn);
```

## Assembler Symbols

<Xn> Is the 64-bit name of the general-purpose register holding the address to be branched to, encoded in the "Rn" field. Defaults to X30 if absent.

## Operation

```
bits(64) target = X[n];

// Value in BTypeNext will be used to set PSTATE.BTYPE
BTypeNext = '00';

BranchTo(target, BranchType_RET, FALSE);
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

RETAA, RETAB

Return from subroutine, with pointer authentication. This instruction authenticates the address that is held in LR, using SP as the modifier and the specified key, branches to the authenticated address, with a hint that this instruction is a subroutine return.

Key A is used for RETAA, and key B is used for RETAB.

If the authentication passes, the PE continues execution at the target of the branch. If the authentication fails, a Translation fault is generated.

The authenticated address is not written back to LR.

Integer  
(FEAT\_PAuth)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	1	0	0	1	0	1	1	1	1	1	0	0	0	0	1	M	1	1	1	1	1	1	1	1	1	1
Z								op				A								Rn						Rm					

RETAA (M == 0)

RETAA

RETAB (M == 1)

RETAB

```
boolean use_key_a = (M == '0');  
  
if !HavePACExt() then  
    UNDEFINED;
```

Operation

```
bits(64) target = X[30];  
  
bits(64) modifier = SP[];  
  
if use_key_a then  
    target = AuthIA(target, modifier, TRUE);  
else  
    target = AuthIB(target, modifier, TRUE);  
  
// Value in BTypeNext will be used to set PSTATE.BTYPE  
BTypeNext = '00';  
  
BranchTo(target, BranchType_RET, FALSE);
```

## REV

Reverse Bytes reverses the byte order in a register.

This instruction is used by the pseudo-instruction [REV64](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	1	0	1	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1	x	Rn				Rd					
opc																															

### 32-bit (sf == 0 && opc == 10)

REV <Wd>, <Wn>

### 64-bit (sf == 1 && opc == 11)

REV <Xd>, <Xn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer datasize = if sf == '1' then 64 else 32;

integer container_size;
case opc of
    when '00'
        Unreachable();
    when '01'
        container_size = 16;
    when '10'
        container_size = 32;
    when '11'
        if sf == '0' then UNDEFINED;
        container_size = 64;
```

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.

## Operation

```
bits(datasize) operand = X[n];
bits(datasize) result;

integer containers = datasize DIV container_size;
integer elements_per_container = container_size DIV 8;
integer index = 0;
integer rev_index;
for c = 0 to containers-1
    rev_index = index + ((elements_per_container - 1) * 8);
    for e = 0 to elements_per_container-1
        result<rev_index+7:rev_index> = operand<index+7:index>;
        index = index + 8;
        rev_index = rev_index - 8;

X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

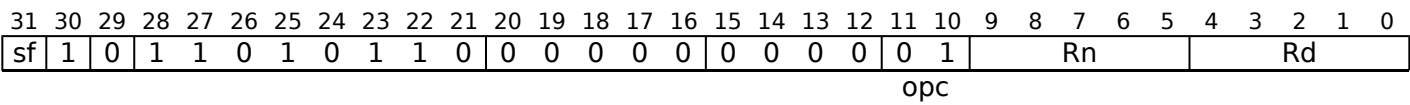
- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# REV16

Reverse bytes in 16-bit halfwords reverses the byte order in each 16-bit halfword of a register.



## 32-bit (sf == 0)

REV16 <Wd>, <Wn>

## 64-bit (sf == 1)

REV16 <Xd>, <Xn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer datasize = if sf == '1' then 64 else 32;

integer container_size;
case opc of
  when '00'
    Unreachable();
  when '01'
    container_size = 16;
  when '10'
    container_size = 32;
  when '11'
    if sf == '0' then UNDEFINED;
    container_size = 64;
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.

## Operation

```
bits(datasize) operand = X[n];
bits(datasize) result;

integer containers = datasize DIV container_size;
integer elements_per_container = container_size DIV 8;
integer index = 0;
integer rev_index;
for c = 0 to containers-1
  rev_index = index + ((elements_per_container - 1) * 8);
  for e = 0 to elements_per_container-1
    result<rev_index+7:rev_index> = operand<index+7:index>;
    index = index + 8;
    rev_index = rev_index - 8;

X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



## REV32

Reverse bytes in 32-bit words reverses the byte order in each 32-bit word of a register.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	Rn				Rd					
sf											opc																				

**REV32** <Xd>, <Xn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer datasize = if sf == '1' then 64 else 32;

integer container_size;
case opc of
  when '00'
    Unreachable();
  when '01'
    container_size = 16;
  when '10'
    container_size = 32;
  when '11'
    if sf == '0' then UNDEFINED;
    container_size = 64;
```

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.

## Operation

```
bits(datasize) operand = X[n];
bits(datasize) result;

integer containers = datasize DIV container_size;
integer elements_per_container = container_size DIV 8;
integer index = 0;
integer rev_index;
for c = 0 to containers-1
  rev_index = index + ((elements_per_container - 1) * 8);
  for e = 0 to elements_per_container-1
    result<rev_index+7:rev_index> = operand<index+7:index>;
    index = index + 8;
    rev_index = rev_index - 8;

X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# REV64

Reverse Bytes reverses the byte order in a 64-bit general-purpose register.  
When assembling for Armv8.2, an assembler must support this pseudo-instruction. It is OPTIONAL whether an assembler supports this pseudo-instruction when assembling for an architecture earlier than Armv8.2.

This is a pseudo-instruction of [REV](#). This means:

- The encodings in this description are named to match the encodings of [REV](#).
- The assembler syntax is used only for assembly, and is not used on disassembly.
- The description of [REV](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1	Rn				Rd					
sf											opc																				

## 64-bit

REV64 <Xd>, <Xn>

is equivalent to

[REV](#) <Xd>, <Xn>

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.

## Operation

The description of [REV](#) gives the operational pseudocode for this instruction.

## Operational information

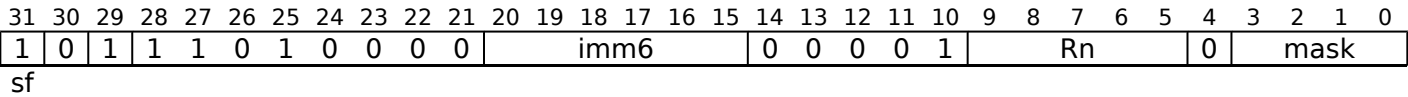
- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# RMIF

Performs a rotation right of a value held in a general purpose register by an immediate value, and then inserts a selection of the bottom four bits of the result of the rotation into the PSTATE flags, under the control of a second immediate mask.

## Integer

(FEAT\_FlagM)



RMIF <Xn>, #<shift>, #<mask>

```
if !HaveFlagManipulateExt() then UNDEFINED;
integer lsb = UInt(imm6);
integer n = UInt(Rn);
```

## Assembler Symbols

- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
- <shift> Is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field,
- <mask> Is the flag bit mask, an immediate in the range 0 to 15, which selects the bits that are inserted into the NZCV condition flags, encoded in the "mask" field.

## Operation

```
bits(4) tmp;
bits(64) tmpreg = X[n];
tmp = (tmpreg:tmpreg)<lsb+3:lsb>;
if mask<3> == '1' then PSTATE.N = tmp<3>;
if mask<2> == '1' then PSTATE.Z = tmp<2>;
if mask<1> == '1' then PSTATE.C = tmp<1>;
if mask<0> == '1' then PSTATE.V = tmp<0>;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# ROR (immediate)

Rotate right (immediate) provides the value of the contents of a register rotated by a variable number of bits. The bits that are rotated off the right end are inserted into the vacated bit positions on the left.

This is an alias of [EXTR](#). This means:

- The encodings in this description are named to match the encodings of [EXTR](#).
  - The description of [EXTR](#) gives the operational pseudocode for this instruction.
- |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |      |    |    |    |    |    |    |   |    |   |   |   |   |   |   |   |   |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|------|----|----|----|----|----|----|---|----|---|---|---|---|---|---|---|---|
| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16   | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8  | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| sf | 0  | 0  | 1  | 0  | 0  | 1  | 1  | 1  | N  | 0  | Rm |    |    |    | imms |    |    |    | Rn |    |    |   | Rd |   |   |   |   |   |   |   |   |

## 32-bit (sf == 0 && N == 0 && imms == 0xxxxx)

ROR <Wd>, <Ws>, #<shift>

is equivalent to

[EXTR](#) <Wd>, <Ws>, <Ws>, #<shift>

and is the preferred disassembly when Rn == Rm.

## 64-bit (sf == 1 && N == 1)

ROR <Xd>, <Xs>, #<shift>

is equivalent to

[EXTR](#) <Xd>, <Xs>, <Xs>, #<shift>

and is the preferred disassembly when Rn == Rm.

## Assembler Symbols

- |         |  |
|---------|--|
| <Wd>    | Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.                   |
| <Ws>    | Is the 32-bit name of the general-purpose source register, encoded in the "Rn" and "Rm" fields.              |
| <Xd>    | Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.                   |
| <Xs>    | Is the 64-bit name of the general-purpose source register, encoded in the "Rn" and "Rm" fields.              |
| <shift> | For the 32-bit variant: is the amount by which to rotate, in the range 0 to 31, encoded in the "imms" field. |
|         | For the 64-bit variant: is the amount by which to rotate, in the range 0 to 63, encoded in the "imms" field. |

## Operation

The description of [EXTR](#) gives the operational pseudocode for this instruction.

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# ROR (register)

Rotate Right (register) provides the value of the contents of a register rotated by a variable number of bits. The bits that are rotated off the right end are inserted into the vacated bit positions on the left. The remainder obtained by dividing the second source register by the data size defines the number of bits by which the first source register is right-shifted.

This is an alias of [RORV](#). This means:

- The encodings in this description are named to match the encodings of [RORV](#).
- The description of [RORV](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	0	1	1	0	1	0	1	1	0	Rm					0	0	1	0	1	1	Rn					Rd				

op2

## 32-bit (sf == 0)

ROR <Wd>, <Wn>, <Wm>

is equivalent to

[RORV](#) <Wd>, <Wn>, <Wm>

and is always the preferred disassembly.

## 64-bit (sf == 1)

ROR <Xd>, <Xn>, <Xm>

is equivalent to

[RORV](#) <Xd>, <Xn>, <Xm>

and is always the preferred disassembly.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Wm>	Is the 32-bit name of the second general-purpose source register holding a shift amount from 0 to 31 in its bottom 5 bits, encoded in the "Rm" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the second general-purpose source register holding a shift amount from 0 to 63 in its bottom 6 bits, encoded in the "Rm" field.

## Operation

The description of [RORV](#) gives the operational pseudocode for this instruction.

## Operational information

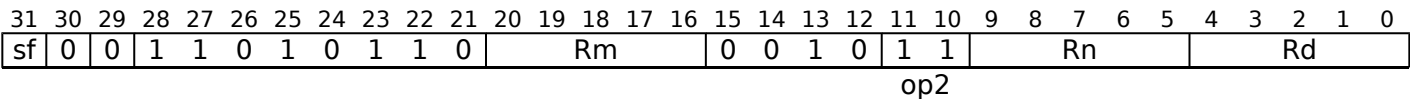
- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.



# RORV

Rotate Right Variable provides the value of the contents of a register rotated by a variable number of bits. The bits that are rotated off the right end are inserted into the vacated bit positions on the left. The remainder obtained by dividing the second source register by the data size defines the number of bits by which the first source register is right-shifted.

This instruction is used by the alias [ROR \(register\)](#).



## 32-bit (sf == 0)

RORV <Wd>, <Wn>, <Wm>

## 64-bit (sf == 1)

RORV <Xd>, <Xn>, <Xm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
ShiftType shift_type = DecodeShift(op2);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register holding a shift amount from 0 to 31 in its bottom 5 bits, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register holding a shift amount from 0 to 63 in its bottom 6 bits, encoded in the "Rm" field.

## Operation

```
bits(datasize) result;
bits(datasize) operand2 = X[m];

result = ShiftReg(n, shift_type, UInt(operand2) MOD datasize);
X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

SB

Speculation Barrier is a barrier that controls speculation.

The semantics of the Speculation Barrier are that the execution, until the barrier completes, of any instruction that appears later in the program order than the barrier:

- Cannot be performed speculatively to the extent that such speculation can be observed through side-channels as a result of control flow speculation or data value speculation.
- Can be speculatively executed as a result of predicting that a potentially exception generating instruction has not generated an exception.

In particular, any instruction that appears later in the program order than the barrier cannot cause a speculative allocation into any caching structure where the allocation of that entry could be indicative of any data value present in memory or in the registers.

The SB instruction:

- Cannot be speculatively executed as a result of control flow speculation or data value speculation.
- Can be speculatively executed as a result of predicting that a potentially exception generating instruction has not generated an exception. The potentially exception generating instruction can complete once it is known not to be speculative, and all data values generated by instructions appearing in program order before the SB instruction have their predicted values confirmed.

When the prediction of the instruction stream is not informed by data taken from the register outputs of the speculative execution of instructions appearing in program order after an uncompleted SB instruction, the SB instruction has no effect on the use of prediction resources to predict the instruction stream that is being fetched.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	1	(0)	(0)	(0)	(0)	1	1	1	1	1	1	1	1
																CRm				opc											

SB

```
if !HaveSBExt() then UNDEFINED;
```

Operation

```
SpeculationBarrier();
```



# SBC

Subtract with Carry subtracts a register value and the value of NOT (Carry flag) from a register value, and writes the result to the destination register.

This instruction is used by the alias [NGC](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf		1	0	1	1	0	1	0	0	0	Rm				0	0	0	0	0	0	Rn				Rd						
op S																															

## 32-bit (sf == 0)

SBC <Wd>, <Wn>, <Wm>

## 64-bit (sf == 1)

SBC <Xd>, <Xn>, <Xm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
```

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Wm>	Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">NGC</a>	Rn == '11111'

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = X[m];

operand2 = NOT(operand2);

(result, -) = AddWithCarry(operand1, operand2, PSTATE.C);

X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.

- The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SBCS

Subtract with Carry, setting flags, subtracts a register value and the value of NOT (Carry flag) from a register value, and writes the result to the destination register. It updates the condition flags based on the result.

This instruction is used by the alias [NGCS](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf		1	1	1	1	0	1	0	0	0	Rm				0	0	0	0	0	0	Rn				Rd						
op S																															

## 32-bit (sf == 0)

SBCS <Wd>, <Wn>, <Wm>

## 64-bit (sf == 1)

SBCS <Xd>, <Xn>, <Xm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
```

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Wm>	Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">NGCS</a>	Rn == '11111'

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = X[m];
bits(4) nzcvc;

operand2 = NOT(operand2);

(result, nzcvc) = AddWithCarry(operand1, operand2, PSTATE.C);

PSTATE.<N,Z,C,V> = nzcvc;

X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.

- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SBFIZ

Signed Bitfield Insert in Zeros copies a bitfield of <width> bits from the least significant bits of the source register to bit position <lsb> of the destination register, setting the destination bits below the bitfield to zero, and the bits above the bitfield to a copy of the most significant bit of the bitfield.

This is an alias of [SBFM](#). This means:

- The encodings in this description are named to match the encodings of [SBFM](#).
- The description of [SBFM](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	0	1	0	0	1	1	0	N	immr					imms					Rn					Rd						
opc																															

## 32-bit (sf == 0 && N == 0)

SBFIZ <Wd>, <Wn>, #<lsb>, #<width>

is equivalent to

[SBFM](#) <Wd>, <Wn>, #(-<lsb> MOD 32), #(<width>-1)

and is the preferred disassembly when `UInt(imms) < UInt(immr)`.

## 64-bit (sf == 1 && N == 1)

SBFIZ <Xd>, <Xn>, #<lsb>, #<width>

is equivalent to

[SBFM](#) <Xd>, <Xn>, #(-<lsb> MOD 64), #(<width>-1)

and is the preferred disassembly when `UInt(imms) < UInt(immr)`.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
<lsb>	For the 32-bit variant: is the bit number of the lsb of the destination bitfield, in the range 0 to 31. For the 64-bit variant: is the bit number of the lsb of the destination bitfield, in the range 0 to 63.
<width>	For the 32-bit variant: is the width of the bitfield, in the range 1 to 32-<lsb>. For the 64-bit variant: is the width of the bitfield, in the range 1 to 64-<lsb>.

## Operation

The description of [SBFM](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.



SBFM

Signed Bitfield Move is usually accessed via one of its aliases, which are always preferred for disassembly.

If <imms> is greater than or equal to <immr>, this copies a bitfield of (<imms>-<immr>+1) bits starting from bit position <immr> in the source register to the least significant bits of the destination register.

If <imms> is less than <immr>, this copies a bitfield of (<imms>+1) bits from the least significant bits of the source register to bit position (regsize-<immr>) of the destination register, where regsize is the destination register size of 32 or 64 bits.

In both cases the destination bits below the bitfield are set to zero, and the bits above the bitfield are set to a copy of the most significant bit of the bitfield.

This instruction is used by the aliases [ASR \(immediate\)](#), [SBFIZ](#), [SBFX](#), [SXTB](#), [SXTH](#), and [SXTW](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	0	1	0	0	1	1	0	N	immr						imms						Rn				Rd					
opc																															

32-bit (sf == 0 && N == 0)

```
SBFM <Wd>, <Wn>, #<immr>, #<imms>
```

64-bit (sf == 1 && N == 1)

```
SBFM <Xd>, <Xn>, #<immr>, #<imms>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer datasize = if sf == '1' then 64 else 32;

integer R;
integer S;
bits(datasize) wmask;
bits(datasize) tmask;

if sf == '1' && N != '1' then UNDEFINED;
if sf == '0' && (N != '0' || immr<5> != '0' || imms<5> != '0') then UNDEFINED;

R = UInt(immr);
S = UInt(imms);
(wmask, tmask) = DecodeBitMasks(N, imms, immr, FALSE);
```

Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
- <immr> For the 32-bit variant: is the right rotate amount, in the range 0 to 31, encoded in the "immr" field.  
For the 64-bit variant: is the right rotate amount, in the range 0 to 63, encoded in the "immr" field.
- <imms> For the 32-bit variant: is the leftmost bit number to be moved from the source, in the range 0 to 31, encoded in the "imms" field.  
For the 64-bit variant: is the leftmost bit number to be moved from the source, in the range 0 to 63, encoded in the "imms" field.

Alias Conditions

Alias	Of variant	Is preferred when
<a href="#">ASR (immediate)</a>	32-bit	imms == '011111'

Alias	Of variant	Is preferred when
<a href="#">ASR (immediate)</a>	64-bit	<code>imms == '111111'</code>
<a href="#">SBEIZ</a>		<code>UInt(imms) &lt; UInt(immr)</code>
<a href="#">SBFX</a>		<code>BFXPreferred(sf, opc&lt;1&gt;, imms, immr)</code>
<a href="#">SXTB</a>		<code>immr == '000000' &amp;&amp; imms == '000111'</code>
<a href="#">SXTH</a>		<code>immr == '000000' &amp;&amp; imms == '001111'</code>
<a href="#">SXTW</a>		<code>immr == '000000' &amp;&amp; imms == '011111'</code>

## Operation

```
bits(datasize) src = X[n];

// perform bitfield move on low bits
bits(datasize) bot = ROR(src, R) AND wmask;

// determine extension bits (sign, zero or dest register)
bits(datasize) top = Replicate(src<S>);

// combine extension bits and result bits
X[d] = (top AND NOT(tmask)) OR (bot AND tmask);
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# SBFX

Signed Bitfield Extract copies a bitfield of <width> bits starting from bit position <lsb> in the source register to the least significant bits of the destination register, and sets destination bits above the bitfield to a copy of the most significant bit of the bitfield.

This is an alias of [SBFM](#). This means:

- The encodings in this description are named to match the encodings of [SBFM](#).
- The description of [SBFM](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf		0	0	1	0	0	1	1	0	N	immr					imms					Rn					Rd					
opc																															

## 32-bit (sf == 0 && N == 0)

SBFX <Wd>, <Wn>, #<lsb>, #<width>

is equivalent to

[SBFM](#) <Wd>, <Wn>, #<lsb>, #(<lsb>+<width>-1)

and is the preferred disassembly when `BFXPreferred(sf, opc<1>, imms, immr)`.

## 64-bit (sf == 1 && N == 1)

SBFX <Xd>, <Xn>, #<lsb>, #<width>

is equivalent to

[SBFM](#) <Xd>, <Xn>, #<lsb>, #(<lsb>+<width>-1)

and is the preferred disassembly when `BFXPreferred(sf, opc<1>, imms, immr)`.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
<lsb>	For the 32-bit variant: is the bit number of the lsb of the source bitfield, in the range 0 to 31. For the 64-bit variant: is the bit number of the lsb of the source bitfield, in the range 0 to 63.
<width>	For the 32-bit variant: is the width of the bitfield, in the range 1 to 32-<lsb>. For the 64-bit variant: is the width of the bitfield, in the range 1 to 64-<lsb>.

## Operation

The description of [SBFM](#) gives the operational pseudocode for this instruction.

## Operational information

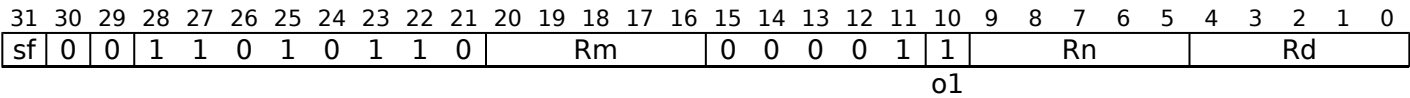
If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.



# SDIV

Signed Divide divides a signed integer register value by another signed integer register value, and writes the result to the destination register. The condition flags are not affected.



## 32-bit (sf == 0)

```
SDIV <Wd>, <Wn>, <Wm>
```

## 64-bit (sf == 1)

```
SDIV <Xd>, <Xn>, <Xm>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.

## Operation

```
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = X[m];
integer result;

if IsZero(operand2) then
    result = 0;
else
    result = RoundTowardsZero(Real(Int(operand1, FALSE)) / Real(Int(operand2, FALSE)));

X[d] = result<datasize-1:0>;
```

# SETF8, SETF16

Set the PSTATE.NZV flags based on the value in the specified general-purpose register. SETF8 treats the value as an 8 bit value, and SETF16 treats the value as an 16 bit value.  
The PSTATE.C flag is not affected by these instructions.

## Integer (FEAT\_FlagM)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	sz	0	0	1	0	Rn				0	1	1	0	1	
sf																															

### SETF8 (sz == 0)

SETF8 <Wn>

### SETF16 (sz == 1)

SETF16 <Wn>

```
if !HaveFlagManipulateExt() then UNDEFINED;
integer msb = if sz == '1' then 15 else 7;
integer n = UInt(Rn);
```

## Assembler Symbols

<Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.

## Operation

```
bits(32) tmpreg = X[n];
PSTATE.N = tmpreg<msb>;
PSTATE.Z = if (tmpreg<msb:0> == Zeros(msb + 1)) then '1' else '0';
PSTATE.V = tmpreg<msb+1> EOR tmpreg<msb>;
//PSTATE.C unchanged;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

SEV

Send Event is a hint instruction. It causes an event to be signaled to all PEs in the multiprocessor system. For more information, see *Wait for Event mechanism and Send event*.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	1	0	0	1	1	1	1	1
																CRm				op2											

SEV

// Empty.

Operation

[SendEvent\(\)](#);

SEVL

Send Event Local is a hint instruction that causes an event to be signaled locally without requiring the event to be signaled to other PEs in the multiprocessor system. It can prime a wait-loop which starts with a WFE instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	1	0	1	1	1	1	1	1
																CRm				op2											

SEVL

// Empty.

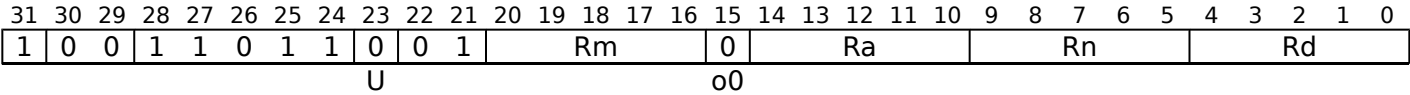
Operation

```
SendEventLocal();
```

# SMADDL

Signed Multiply-Add Long multiplies two 32-bit register values, adds a 64-bit register value, and writes the result to the 64-bit destination register.

This instruction is used by the alias [SMULL](#).



SMADDL <Xd>, <Wn>, <Wm>, <Xa>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer a = UInt(Ra);
```

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.
- <Xa> Is the 64-bit name of the third general-purpose source register holding the addend, encoded in the "Ra" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">SMULL</a>	Ra == '11111'

## Operation

```
bits(32) operand1 = X[n];
bits(32) operand2 = X[m];
bits(64) operand3 = X[a];

integer result;

result = Int(operand3, FALSE) + (Int(operand1, FALSE) * Int(operand2, FALSE));
X[d] = result<63:0>;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SMC

Secure Monitor Call causes an exception to EL3.  
SMC is available only for software executing at EL1 or higher. It is UNDEFINED in EL0.  
If the values of *HCR\_EL2.TSC* and *SCR\_EL3.SMD* are both 0, execution of an SMC instruction at EL1 or higher generates a Secure Monitor Call exception, recording it in *ESR\_ELx*, using the EC value 0x17, that is taken to EL3.  
If the value of *HCR\_EL2.TSC* is 1 and EL2 is enabled in the current Security state, execution of an SMC instruction at EL1 generates an exception that is taken to EL2, regardless of the value of *SCR\_EL3.SMD*. For more information, see *Traps to EL2 of Non-secure EL1 execution of SMC instructions*.  
If the value of *HCR\_EL2.TSC* is 0 and the value of *SCR\_EL3.SMD* is 1, the SMC instruction is UNDEFINED.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	0	0	0	0	imm16																0	0	0	1	1

SMC #<imm>

// Empty.

## Assembler Symbols

<imm> Is a 16-bit unsigned immediate, in the range 0 to 65535, encoded in the "imm16" field.

## Operation

```
AArch64.CheckForSMCUndef0rTrap(imm16);
AArch64.CallSecureMonitor(imm16);
```

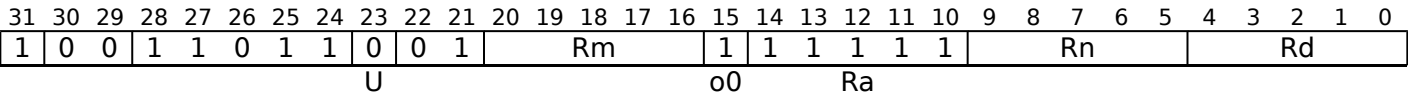


# SMNEGL

Signed Multiply-Negate Long multiplies two 32-bit register values, negates the product, and writes the result to the 64-bit destination register.

This is an alias of [SMSUBL](#). This means:

- The encodings in this description are named to match the encodings of [SMSUBL](#).
- The description of [SMSUBL](#) gives the operational pseudocode for this instruction.



SMNEGL <Xd>, <Wn>, <Wm>

is equivalent to

[SMSUBL](#) <Xd>, <Wn>, <Wm>, XZR

and is always the preferred disassembly.

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.

## Operation

The description of [SMSUBL](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

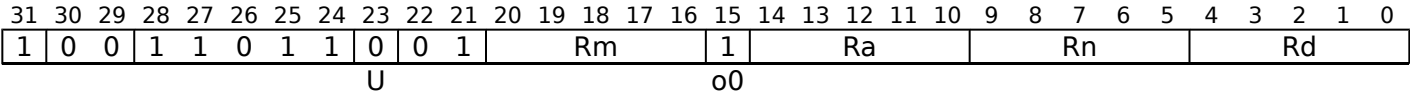
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SMSUBL

Signed Multiply-Subtract Long multiplies two 32-bit register values, subtracts the product from a 64-bit register value, and writes the result to the 64-bit destination register.

This instruction is used by the alias [SMNEGL](#).



SMSUBL <Xd>, <Wn>, <Wm>, <Xa>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer a = UInt(Ra);
```

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.
- <Xa> Is the 64-bit name of the third general-purpose source register holding the minuend, encoded in the "Ra" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">SMNEGL</a>	Ra == '11111'

## Operation

```
bits(32) operand1 = X[n];
bits(32) operand2 = X[m];
bits(64) operand3 = X[a];

integer result;

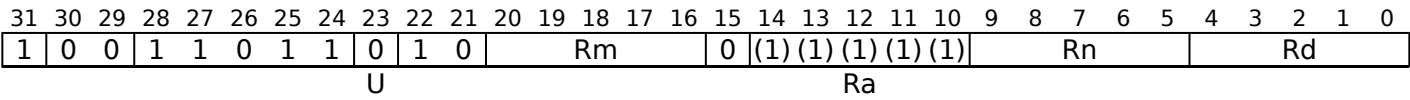
result = Int(operand3, FALSE) - (Int(operand1, FALSE) * Int(operand2, FALSE));
X[d] = result<63:0>;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SMULH

Signed Multiply High multiplies two 64-bit register values, and writes bits[127:64] of the 128-bit result to the 64-bit destination register.



SMULH <Xd>, <Xn>, <Xm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
```

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.

## Operation

```
bits(64) operand1 = X[n];
bits(64) operand2 = X[m];

integer result;

result = Int(operand1, FALSE) * Int(operand2, FALSE);

X[d] = result<127:64>;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SMULL

Signed Multiply Long multiplies two 32-bit register values, and writes the result to the 64-bit destination register.

This is an alias of [SMADDL](#). This means:

- The encodings in this description are named to match the encodings of [SMADDL](#).
- The description of [SMADDL](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	1	0	1	1	0	0	1	Rm				0	1	1	1	1	1	Rn				Rd						
U								o0				Ra																			

SMULL <Xd>, <Wn>, <Wm>

is equivalent to

[SMADDL](#) <Xd>, <Wn>, <Wm>, XZR

and is always the preferred disassembly.

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.

## Operation

The description of [SMADDL](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SSBB

Speculative Store Bypass Barrier is a memory barrier which prevents speculative loads from bypassing earlier stores to the same virtual address under certain conditions.

The semantics of the Speculative Store Bypass Barrier are:

- When a load to a location appears in program order after the SSBB, then the load does not speculatively read an entry earlier in the coherence order for that location than the entry generated by the latest store satisfying all of the following conditions:
  - The store is to the same location as the load.
  - The store uses the same virtual address as the load.
  - The store appears in program order before the SSBB.
- When a load to a location appears in program order before the SSBB, then the load does not speculatively read data from any store satisfying all of the following conditions:
  - The store is to the same location as the load.
  - The store uses the same virtual address as the load.
  - The store appears in program order after the SSBB.

This is an alias of [DSB](#). This means:

- The encodings in this description are named to match the encodings of [DSB](#).
- The description of [DSB](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	1	0	0	0	0	1	0	0	1	1	1	1	1
																CRm				opc											

SSBB

is equivalent to

[DSB](#) #0

and is always the preferred disassembly.

Operation

The description of [DSB](#) gives the operational pseudocode for this instruction.

## ST2G

Store Allocation Tags stores an Allocation Tag to two Tag granules of memory. The address used for the store is calculated from the base register and an immediate signed offset scaled by the Tag granule. The Allocation Tag is calculated from the Logical Address Tag in the source register.

This instruction generates an Unchecked access.

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Signed offset](#)

### Post-index (FEAT\_MTE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	1	0	1	imm9									0	1	Xn				Xt					

ST2G <Xt|SP>, [<Xn|SP>], #<simm>

```
if !HaveMTEExt() then UNDEFINED;
integer n = UInt(Xn);
integer t = UInt(Xt);
bits(64) offset = LSL(SignExtend(imm9, 64), LOG2_TAG_GRANULE);
boolean writeback = TRUE;
boolean postindex = TRUE;
```

### Pre-index (FEAT\_MTE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	1	0	1	imm9									1	1	Xn				Xt					

ST2G <Xt|SP>, [<Xn|SP>, #<simm>]!

```
if !HaveMTEExt() then UNDEFINED;
integer n = UInt(Xn);
integer t = UInt(Xt);
bits(64) offset = LSL(SignExtend(imm9, 64), LOG2_TAG_GRANULE);
boolean writeback = TRUE;
boolean postindex = FALSE;
```

### Signed offset (FEAT\_MTE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	1	0	1	imm9									1	0	Xn				Xt					

ST2G <Xt|SP>, [<Xn|SP>{, #<simm>}]

```
if !HaveMTEExt() then UNDEFINED;
integer n = UInt(Xn);
integer t = UInt(Xt);
bits(64) offset = LSL(SignExtend(imm9, 64), LOG2_TAG_GRANULE);
boolean writeback = FALSE;
boolean postindex = FALSE;
```

## Assembler Symbols

- <Xt|SP> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Xt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Xn" field.

<sim> Is the optional signed immediate offset, a multiple of 16 in the range -4096 to 4080, defaulting to 0 and encoded in the "imm9" field.

## Operation

```
bits(64) address;
bits(64) data = if t == 31 then SP[] else X[t];
bits(4) tag = AArch64.AllocationTagFromAddress(data);

SetTagCheckedInstruction(FALSE);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

AArch64.MemTag[address, AccType_NORMAL] = tag;
AArch64.MemTag[address+TAG_GRANULE, AccType_NORMAL] = tag;

if writeback then
    if postindex then
        address = address + offset;

    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

ST64B

Single-copy Atomic 64-byte Store without Return stores eight 64-bit doublewords from consecutive registers, Xt to X(t+7), to a memory location. The data that is stored is atomic and is required to be 64-byte-aligned.

Integer  
(FEAT\_LS64)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	1	1	0	0	1	0	0	Rn				Rt					

ST64B <Xt>, [<Xn|SP> {, #0}]

```
if !HaveFeatLS64() then UNDEFINED;
if Rt<4:3> == '11' || Rt<0> == '1' then UNDEFINED;

integer n = UInt(Rn);
integer t = UInt(Rt);
boolean tag_checked = n != 31;
```

Assembler Symbols

- <Xt> Is the 64-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Operation

```
CheckLDST64BEnabled();

bits(512) data;
bits(64) address;
bits(64) value;
acctype = AccType_ATOMICLS64;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

for i = 0 to 7
    value = X[t+i];
    if BigEndian(acctype) then value = BigEndianReverse(value);
    data<63+64*i:64*i> = value;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

MemStore64B(address, data, acctype);
```



ST64BV

Single-copy Atomic 64-byte Store with Return stores eight 64-bit doublewords from consecutive registers, Xt to X(t+7), to a memory location, and writes the status result of the store to a register. The data that is stored is atomic and is required to be 64-byte aligned.

Integer  
(FEAT\_LS64\_V)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	1	1	0	0	0	0	0	1	Rs					1	0	1	1	0	0	Rn				Rt					

ST64BV <Xs>, <Xt>, [<Xn|SP>]

```
if !HaveFeatLS64() then UNDEFINED;
if Rt<4:3> == '11' || Rt<0> == '1' then UNDEFINED;

integer n = UInt(Rn);
integer t = UInt(Rt);
integer s = UInt(Rs);
boolean tag_checked = n != 31;
```

Assembler Symbols

- <Xs> Is the 64-bit name of the general-purpose register into which the status result of this instruction is written, encoded in the "Rs" field.  
The value returned is:  
**0** If the operation updates memory.  
**1** If the operation fails to update memory.  
**0xFFFFFFFF\_FFFFFFFF** If the memory location accessed does not support this instruction.  
If XZR is used, then the return value is ignored.
- <Xt> Is the 64-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
CheckST64BVEnabled();

bits(512) data;
bits(64) address;
bits(64) value;
bits(64) status;
acctype = AccType_ATOMICLS64;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

for i = 0 to 7
    value = X[t+i];
    if BigEndian(acctype) then value = BigEndianReverse(value);
    data<63+64*i:64*i> = value;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

status = MemStore64BWithRet(address, data, acctype);

if s != 31 then X[s] = status;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# ST64BV0

Single-copy Atomic 64-byte EL0 Store with Return stores eight 64-bit doublewords from consecutive registers, Xt to X(t+7), to a memory location, with the bottom 32 bits taken from *ACCDATA\_EL1*, and writes the status result of the store to a register. The data that is stored is atomic and is required to be 64-byte aligned.

## Integer (FEAT\_LS64\_V)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	1	1	0	0	0	0	0	1	Rs					1	0	1	0	0	0	Rn					Rt				

ST64BV0 <Xs>, <Xt>, [<Xn|SP>]

```
if !HaveFeatLS64() then UNDEFINED;
if Rt<4:3> == '11' || Rt<0> == '1' then UNDEFINED;

integer n = UInt(Rn);
integer t = UInt(Rt);
integer s = UInt(Rs);
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Xs> Is the 64-bit name of the general-purpose register into which the status result of this instruction is written, encoded in the "Rs" field.  
The value returned is:  
**0** If the operation updates memory.  
**1** If the operation fails to update memory.  
**0xFFFFFFFF\_FFFFFFFF** If the memory location accessed does not support this instruction.  
If XZR is used, then the return value is ignored.
- <Xt> Is the 64-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
CheckST64BV0Enabled();

bits(512) data;
bits(64) address;
bits(64) value;
bits(64) status;
acctype = AccType_ATOMICLS64;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) Xt = X[t];
value<31:0> = ACCDATA_EL1<31:0>;
value<63:32> = Xt<63:32>;
if BigEndian(acctype) then value = BigEndianReverse(value);
data<63:0> = value;
for i = 1 to 7
    value = X[t+i];
    if BigEndian(acctype) then value = BigEndianReverse(value);
    data<63+64*i:64*i> = value;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

status = MemStore64BWithRet(address, data, acctype);

if s != 31 then X[s] = status;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# STADD, STADDL

Atomic add on word or doubleword in memory, without return, atomically loads a 32-bit word or 64-bit doubleword from memory, adds the value held in a register to it, and stores the result back to memory.

- STADD does not have release semantics.
  - STADDL stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.
- For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDADD, LDADDA, LDADDAL, LDADDL](#). This means:

- The encodings in this description are named to match the encodings of [LDADD, LDADDA, LDADDAL, LDADDL](#).
- The description of [LDADD, LDADDA, LDADDAL, LDADDL](#) gives the operational pseudocode for this instruction.

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	0	0	R	1	Rs				0	0	0	0	0	0	Rn				1	1	1	1	1		
size				A				opc																Rt							

### 32-bit LDADD alias (size == 10 && R == 0)

STADD <Ws>, [<Xn|SP>]

is equivalent to

LDADD <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### 32-bit LDADDL alias (size == 10 && R == 1)

STADDL <Ws>, [<Xn|SP>]

is equivalent to

LDADDL <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### 64-bit LDADD alias (size == 11 && R == 0)

STADD <Xs>, [<Xn|SP>]

is equivalent to

LDADD <Xs>, XZR, [<Xn|SP>]

and is always the preferred disassembly.

### 64-bit LDADDL alias (size == 11 && R == 1)

STADDL <Xs>, [<Xn|SP>]

is equivalent to

LDADDL <Xs>, XZR, [<Xn|SP>]

and is always the preferred disassembly.

## Assembler Symbols

<Ws>	Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xs>	Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDADD](#), [LDADDA](#), [LDADDAL](#), [LDADDL](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# STADDB, STADDLB

Atomic add on byte in memory, without return, atomically loads an 8-bit byte from memory, adds the value held in a register to it, and stores the result back to memory.

- STADDB does not have release semantics.
  - STADDLB stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.
- For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDADDB, LDADDAB, LDADDALB, LDADDLB](#). This means:

- The encodings in this description are named to match the encodings of [LDADDB, LDADDAB, LDADDALB, LDADDLB](#).
- The description of [LDADDB, LDADDAB, LDADDALB, LDADDLB](#) gives the operational pseudocode for this instruction.

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	0	R	1	Rs				0	0	0	0	0	0	Rn				1	1	1	1	1		
size									A							opc							Rt								

### No memory ordering (R == 0)

STADDB <Ws>, [<Xn|SP>]

is equivalent to

[LDADDB](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### Release (R == 1)

STADDLB <Ws>, [<Xn|SP>]

is equivalent to

[LDADDLB](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDADDB, LDADDAB, LDADDALB, LDADDLB](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

# STADDH, STADDLH

Atomic add on halfword in memory, without return, atomically loads a 16-bit halfword from memory, adds the value held in a register to it, and stores the result back to memory.

- STADDH does not have release semantics.
  - STADDLH stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.
- For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDADDH, LDADDAH, LDADDALH, LDADDLH](#). This means:

- The encodings in this description are named to match the encodings of [LDADDH, LDADDAH, LDADDALH, LDADDLH](#).
- The description of [LDADDH, LDADDAH, LDADDALH, LDADDLH](#) gives the operational pseudocode for this instruction.

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	0	R	1	Rs				0	0	0	0	0	0	Rn				1	1	1	1	1		
size								A				opc								Rt											

### No memory ordering (R == 0)

STADDH *<Ws>*, [*<Xn|SP>*]  
is equivalent to  
[LDADDH](#) *<Ws>*, WZR, [*<Xn|SP>*]  
and is always the preferred disassembly.

### Release (R == 1)

STADDLH *<Ws>*, [*<Xn|SP>*]  
is equivalent to  
[LDADDLH](#) *<Ws>*, WZR, [*<Xn|SP>*]  
and is always the preferred disassembly.

## Assembler Symbols

- <Ws>* Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP>* Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDADDH, LDADDAH, LDADDALH, LDADDLH](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.



# STCLR, STCLRL

Atomic bit clear on word or doubleword in memory, without return, atomically loads a 32-bit word or 64-bit doubleword from memory, performs a bitwise AND with the complement of the value held in a register on it, and stores the result back to memory.

- STCLR does not have release semantics.
  - STCLRL stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.
- For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDCLR, LDCLRA, LDCLRAL, LDCLRL](#). This means:

- The encodings in this description are named to match the encodings of [LDCLR, LDCLRA, LDCLRAL, LDCLRL](#).
- The description of [LDCLR, LDCLRA, LDCLRAL, LDCLRL](#) gives the operational pseudocode for this instruction.

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	0	0	R	1	Rs				0	0	0	1	0	0	Rn				1	1	1	1	1		
size								A				opc								Rt											

### 32-bit LDCLR alias (size == 10 && R == 0)

STCLR *<Ws>*, [*<Xn|SP>*]

is equivalent to

*LDCLR* *<Ws>*, WZR, [*<Xn|SP>*]

and is always the preferred disassembly.

### 32-bit LDCLRL alias (size == 10 && R == 1)

STCLRL *<Ws>*, [*<Xn|SP>*]

is equivalent to

*LDCLRL* *<Ws>*, WZR, [*<Xn|SP>*]

and is always the preferred disassembly.

### 64-bit LDCLR alias (size == 11 && R == 0)

STCLR *<Xs>*, [*<Xn|SP>*]

is equivalent to

*LDCLR* *<Xs>*, XZR, [*<Xn|SP>*]

and is always the preferred disassembly.

### 64-bit LDCLRL alias (size == 11 && R == 1)

STCLRL *<Xs>*, [*<Xn|SP>*]

is equivalent to

*LDCLRL* *<Xs>*, XZR, [*<Xn|SP>*]

and is always the preferred disassembly.

## Assembler Symbols

<Ws>	Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xs>	Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDCLR](#), [LDCLRA](#), [LDCLRAL](#), [LDCLRL](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# STCLRB, STCLRLB

Atomic bit clear on byte in memory, without return, atomically loads an 8-bit byte from memory, performs a bitwise AND with the complement of the value held in a register on it, and stores the result back to memory.

- STCLRB does not have release semantics.
  - STCLRLB stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.
- For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDCLRB, LDCLRAB, LDCLRALB, LDCLRLB](#). This means:

- The encodings in this description are named to match the encodings of [LDCLRB, LDCLRAB, LDCLRALB, LDCLRLB](#).
- The description of [LDCLRB, LDCLRAB, LDCLRALB, LDCLRLB](#) gives the operational pseudocode for this instruction.

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	0	R	1	Rs				0	0	0	1	0	0	Rn				1	1	1	1	1		
size								A				opc								Rt											

### No memory ordering (R == 0)

STCLRB <Ws>, [<Xn|SP>]

is equivalent to

[LDCLRB](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### Release (R == 1)

STCLRLB <Ws>, [<Xn|SP>]

is equivalent to

[LDCLRLB](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDCLRB, LDCLRAB, LDCLRALB, LDCLRLB](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

# STCLR<sub>H</sub>, STCLR<sub>LH</sub>

Atomic bit clear on halfword in memory, without return, atomically loads a 16-bit halfword from memory, performs a bitwise AND with the complement of the value held in a register on it, and stores the result back to memory.

- STCLR<sub>H</sub> does not have release semantics.
  - STCLR<sub>LH</sub> stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.
- For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDCLR<sub>H</sub>](#), [LDCLR<sub>RAH</sub>](#), [LDCLR<sub>ALH</sub>](#), [LDCLR<sub>LH</sub>](#). This means:

- The encodings in this description are named to match the encodings of [LDCLR<sub>H</sub>](#), [LDCLR<sub>RAH</sub>](#), [LDCLR<sub>ALH</sub>](#), [LDCLR<sub>LH</sub>](#).
- The description of [LDCLR<sub>H</sub>](#), [LDCLR<sub>RAH</sub>](#), [LDCLR<sub>ALH</sub>](#), [LDCLR<sub>LH</sub>](#) gives the operational pseudocode for this instruction.

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	0	R	1	Rs				0	0	0	1	0	0	Rn				1	1	1	1	1		
size								A				opc								Rt											

### No memory ordering (R == 0)

STCLR<sub>H</sub> <Ws>, [<Xn|SP>]

is equivalent to

[LDCLR<sub>H</sub>](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### Release (R == 1)

STCLR<sub>LH</sub> <Ws>, [<Xn|SP>]

is equivalent to

[LDCLR<sub>LH</sub>](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDCLR<sub>H</sub>](#), [LDCLR<sub>RAH</sub>](#), [LDCLR<sub>ALH</sub>](#), [LDCLR<sub>LH</sub>](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

# STEOR, STEORL

Atomic exclusive OR on word or doubleword in memory, without return, atomically loads a 32-bit word or 64-bit doubleword from memory, performs an exclusive OR with the value held in a register on it, and stores the result back to memory.

- STEOR does not have release semantics.
- STEORL stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDEOR, LDEORA, LDEORAL, LDEORL](#). This means:

- The encodings in this description are named to match the encodings of [LDEOR, LDEORA, LDEORAL, LDEORL](#).
- The description of [LDEOR, LDEORA, LDEORAL, LDEORL](#) gives the operational pseudocode for this instruction.

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	0	0	R	1	Rs				0	0	1	0	0	0	Rn				1	1	1	1	1		
size				A				opc																Rt							

### 32-bit LDEOR alias (size == 10 && R == 0)

STEOR <Ws>, [<Xn|SP>]

is equivalent to

LDEOR <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### 32-bit LDEORL alias (size == 10 && R == 1)

STEORL <Ws>, [<Xn|SP>]

is equivalent to

LDEORL <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### 64-bit LDEOR alias (size == 11 && R == 0)

STEOR <Xs>, [<Xn|SP>]

is equivalent to

LDEOR <Xs>, XZR, [<Xn|SP>]

and is always the preferred disassembly.

### 64-bit LDEORL alias (size == 11 && R == 1)

STEORL <Xs>, [<Xn|SP>]

is equivalent to

LDEORL <Xs>, XZR, [<Xn|SP>]

and is always the preferred disassembly.

## Assembler Symbols

<Ws>	Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xs>	Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDEOR](#), [LDEORA](#), [LDEORAL](#), [LDEORL](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# STEORB, STEORLB

Atomic exclusive OR on byte in memory, without return, atomically loads an 8-bit byte from memory, performs an exclusive OR with the value held in a register on it, and stores the result back to memory.

- STEORB does not have release semantics.
  - STEORLB stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.
- For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDEORB, LDEORAB, LDEORALB, LDEORLB](#). This means:

- The encodings in this description are named to match the encodings of [LDEORB, LDEORAB, LDEORALB, LDEORLB](#).
- The description of [LDEORB, LDEORAB, LDEORALB, LDEORLB](#) gives the operational pseudocode for this instruction.

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	0	R	1	Rs				0	0	1	0	0	0	Rn				1	1	1	1	1		
size								A				opc								Rt											

### No memory ordering (R == 0)

STEORB <Ws>, [<Xn|SP>]

is equivalent to

[LDEORB](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### Release (R == 1)

STEORLB <Ws>, [<Xn|SP>]

is equivalent to

[LDEORLB](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDEORB, LDEORAB, LDEORALB, LDEORLB](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

# STEORH, STEORLH

Atomic exclusive OR on halfword in memory, without return, atomically loads a 16-bit halfword from memory, performs an exclusive OR with the value held in a register on it, and stores the result back to memory.

- STEORH does not have release semantics.
  - STEORLH stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.
- For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDEORH, LDEORAH, LDEORALH, LDEORLH](#). This means:

- The encodings in this description are named to match the encodings of [LDEORH, LDEORAH, LDEORALH, LDEORLH](#).
- The description of [LDEORH, LDEORAH, LDEORALH, LDEORLH](#) gives the operational pseudocode for this instruction.

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	1	1	1	1	0	0	0	0	R	1	Rs				0	0	1	0	0	0	Rn				1	1	1	1	1			
size								A				opc								Rt												

### No memory ordering (R == 0)

STEORH <Ws>, [<Xn|SP>]  
is equivalent to  
[LDEORH](#) <Ws>, WZR, [<Xn|SP>]  
and is always the preferred disassembly.

### Release (R == 1)

STEORLH <Ws>, [<Xn|SP>]  
is equivalent to  
[LDEORLH](#) <Ws>, WZR, [<Xn|SP>]  
and is always the preferred disassembly.

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDEORH, LDEORAH, LDEORALH, LDEORLH](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.



## STG

Store Allocation Tag stores an Allocation Tag to memory. The address used for the store is calculated from the base register and an immediate signed offset scaled by the Tag granule. The Allocation Tag is calculated from the Logical Address Tag in the source register.

This instruction generates an Unchecked access.

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Signed offset](#)

### Post-index (FEAT\_MTE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	0	0	1	imm9									0	1	Xn						Xt			

STG <Xt|SP>, [<Xn|SP>], #<sim>

```
if !HaveMTEExt() then UNDEFINED;
integer n = UInt(Xn);
integer t = UInt(Xt);
bits(64) offset = LSL(SignExtend(imm9, 64), LOG2_TAG_GRANULE);
boolean writeback = TRUE;
boolean postindex = TRUE;
```

### Pre-index (FEAT\_MTE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	0	0	1	imm9									1	1	Xn						Xt			

STG <Xt|SP>, [<Xn|SP>, #<sim>]!

```
if !HaveMTEExt() then UNDEFINED;
integer n = UInt(Xn);
integer t = UInt(Xt);
bits(64) offset = LSL(SignExtend(imm9, 64), LOG2_TAG_GRANULE);
boolean writeback = TRUE;
boolean postindex = FALSE;
```

### Signed offset (FEAT\_MTE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	0	0	1	imm9									1	0	Xn						Xt			

STG <Xt|SP>, [<Xn|SP>{, #<sim>}]

```
if !HaveMTEExt() then UNDEFINED;
integer n = UInt(Xn);
integer t = UInt(Xt);
bits(64) offset = LSL(SignExtend(imm9, 64), LOG2_TAG_GRANULE);
boolean writeback = FALSE;
boolean postindex = FALSE;
```

## Assembler Symbols

- <Xt|SP> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Xt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Xn" field.

<sim> Is the optional signed immediate offset, a multiple of 16 in the range -4096 to 4080, defaulting to 0 and encoded in the "imm9" field.

## Operation

```
bits(64) address;  
  
SetTagCheckedInstruction(FALSE);  
  
if n == 31 then  
    CheckSPAlignment();  
    address = SP[];  
else  
    address = X[n];  
  
if !postindex then  
    address = address + offset;  
  
bits(64) data = if t == 31 then SP[] else X[t];  
bits(4) tag = AArch64.AllocationTagFromAddress(data);  
AArch64.MemTag[address, AccType\_NORMAL] = tag;  
  
if writeback then  
    if postindex then  
        address = address + offset;  
  
    if n == 31 then  
        SP[] = address;  
    else  
        X[n] = address;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

STGM

Store Tag Multiple writes a naturally aligned block of N Allocation Tags, where the size of N is identified in GMID\_EL1.BS, and the Allocation Tag written to address A is taken from the source register at  $4 \times A \ll 7:4 + 3:4 \times A \ll 7:4$ .

This instruction is UNDEFINED at EL0.

This instruction generates an Unchecked access.

If `ID_AA64PFR1_EL1.MTE` != 0b0010, this instruction is UNDEFINED.

Integer  
(FEAT\_MTE2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	Xn					Xt				

STGM <Xt>, [<Xn|SP>]

```
if !HaveMTE2Ext() then UNDEFINED;
integer t = UInt(Xt);
integer n = UInt(Xn);
```

Assembler Symbols

- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Xt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Xn" field.

Operation

```
if PSTATE.EL == EL0 then
    UNDEFINED;

bits(64) data = X[t];
bits(64) address;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

integer size = 4 * (2 ^ (UInt(GMID_EL1.BS)));
address = Align(address, size);
integer count = size >> LOG2_TAG_GRANULE;
integer index = UInt(address < LOG2_TAG_GRANULE + 3 : LOG2_TAG_GRANULE >);

for i = 0 to count-1
    bits(4) tag = data < (index*4)+3 : index*4 >;
    AArch64.MemTag[address, AccType_NORMAL] = tag;
    address = address + TAG_GRANULE;
    index = index + 1;
```

## STGP

Store Allocation Tag and Pair of registers stores an Allocation Tag and two 64-bit doublewords to memory, from two registers. The address used for the store is calculated from the base register and an immediate signed offset scaled by the Tag granule. The Allocation Tag is calculated from the Logical Address Tag in the base register.

This instruction generates an Unchecked access.

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Signed offset](#)

### Post-index (FEAT\_MTE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	0	1	0	simm7							Xt2				Xn				Xt						

STGP <Xt1>, <Xt2>, [<Xn|SP>], #<imm>

```
if !HaveMTEExt() then UNDEFINED;
integer n = UInt(Xn);
integer t = UInt(Xt);
integer t2 = UInt(Xt2);
bits(64) offset = LSL(SignExtend(simm7, 64), LOG2_TAG_GRANULE);
boolean writeback = TRUE;
boolean postindex = TRUE;
```

### Pre-index (FEAT\_MTE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	1	0	simm7							Xt2				Xn				Xt						

STGP <Xt1>, <Xt2>, [<Xn|SP>, #<imm>]!

```
if !HaveMTEExt() then UNDEFINED;
integer n = UInt(Xn);
integer t = UInt(Xt);
integer t2 = UInt(Xt2);
bits(64) offset = LSL(SignExtend(simm7, 64), LOG2_TAG_GRANULE);
boolean writeback = TRUE;
boolean postindex = FALSE;
```

### Signed offset (FEAT\_MTE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	0	0	simm7							Xt2				Xn				Xt						

STGP <Xt1>, <Xt2>, [<Xn|SP>{, #<imm>}]

```
if !HaveMTEExt() then UNDEFINED;
integer n = UInt(Xn);
integer t = UInt(Xt);
integer t2 = UInt(Xt2);
bits(64) offset = LSL(SignExtend(simm7, 64), LOG2_TAG_GRANULE);
boolean writeback = FALSE;
boolean postindex = FALSE;
```

## Assembler Symbols

<Xt1> Is the 64-bit name of the first general-purpose register to be transferred, encoded in the "Xt" field.

<Xt2>	Is the 64-bit name of the second general-purpose register to be transferred, encoded in the "Xt2" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Xn" field.
<imm>	For the post-index and pre-index variant: is the signed immediate offset, a multiple of 16 in the range -1024 to 1008, encoded in the "simm7" field.  For the signed offset variant: is the optional signed immediate offset, a multiple of 16 in the range -1024 to 1008, defaulting to 0 and encoded in the "simm7" field.

## Operation

```

bits(64) address;
bits(64) data1;
bits(64) data2;

SetTagCheckedInstruction(FALSE);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data1 = X[t];
data2 = X[t2];

if !postindex then
    address = address + offset;

if address != Align(address, TAG_GRANULE) then
    AArch64.Abort(address, AlignmentFault(AccType_NORMAL, TRUE, FALSE));

Mem[address, 8, AccType_NORMAL] = data1;
Mem[address+8, 8, AccType_NORMAL] = data2;

AArch64.MemTag[address, AccType_NORMAL] = AArch64.AllocationTagFromAddress(address);

if writeback then
    if postindex then
        address = address + offset;

    if n == 31 then
        SP[] = address;
    else
        X[n] = address;

```

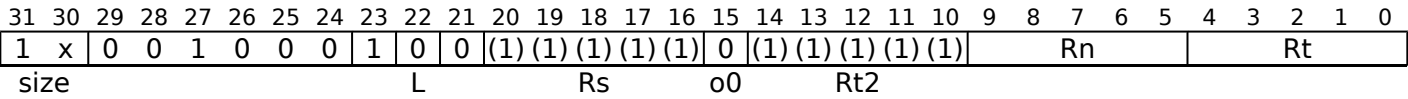
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

STLLR

Store LORelease Register stores a 32-bit word or a 64-bit doubleword to a memory location, from a register. The instruction also has memory ordering semantics as described in *Load LOAcquire, Store LORelease*. For information about memory accesses, see *Load/Store addressing modes*.

No offset  
(FEAT\_LOR)



32-bit (size == 10)

```
STLLR <Wt>, [<Xn|SP>{, #0}]
```

64-bit (size == 11)

```
STLLR <Xt>, [<Xn|SP>{, #0}]

integer n = UInt(Rn);
integer t = UInt(Rt);

integer elsize = 8 << UInt(size);
boolean tag_checked = n != 31;
```

Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Operation

```
bits(64) address;
bits(elsize) data;
constant integer dbytes = elsize DIV 8;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = X[t];
Mem[address, dbytes, AccType_LIMITEDORDERED] = data;
```

Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

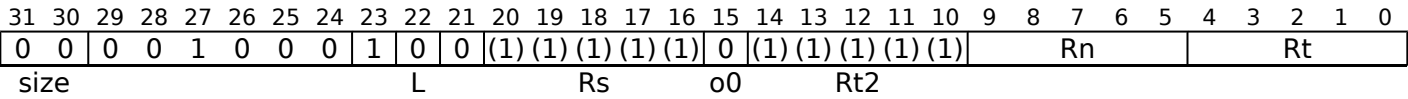
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

STLLRB

Store LORelease Register Byte stores a byte from a 32-bit register to a memory location. The instruction also has memory ordering semantics as described in *Load LOAcquire, Store LORelease*. For information about memory accesses, see *Load/Store addressing modes*.

No offset  
(FEAT\_LOR)



STLLRB <Wt>, [<Xn|SP>{, #0}]

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Operation

```
bits(64) address;
bits(8) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = X[t];
Mem[address, 1, AccType_LIMITEDORDERED] = data;
```

Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

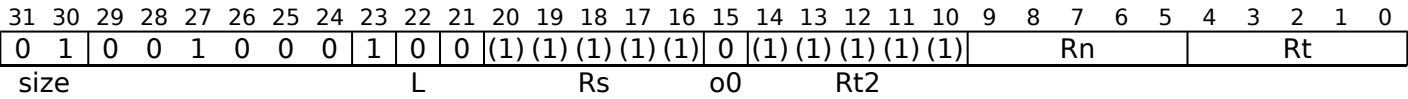
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# STLLRH

Store LORelease Register Halfword stores a halfword from a 32-bit register to a memory location. The instruction also has memory ordering semantics as described in *Load LOAcquire, Store LORelease*. For information about memory accesses, see *Load/Store addressing modes*.

## No offset (FEAT\_LOR)



STLLRH <Wt>, [<Xn|SP>{, #0}]

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(16) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = X[t];
Mem[address, 2, AccType_LIMITEDORDERED] = data;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

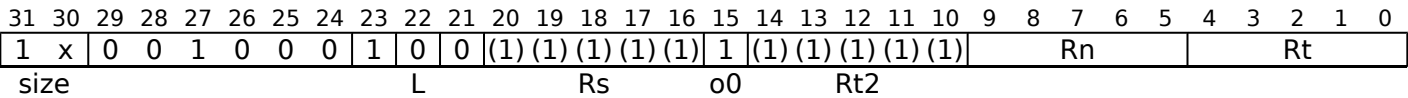
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# STLR

Store-Release Register stores a 32-bit word or a 64-bit doubleword to a memory location, from a register. The instruction also has memory ordering semantics as described in *Load-Acquire, Store-Release*. For information about memory accesses, see *Load/Store addressing modes*.



## 32-bit (size == 10)

STLR <Wt>, [<Xn|SP>{, #0}]

## 64-bit (size == 11)

STLR <Xt>, [<Xn|SP>{, #0}]

```
integer n = UInt(Rn);
integer t = UInt(Rt);

integer elsize = 8 << UInt(size);
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(elsize) data;
constant integer dbytes = elsize DIV 8;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

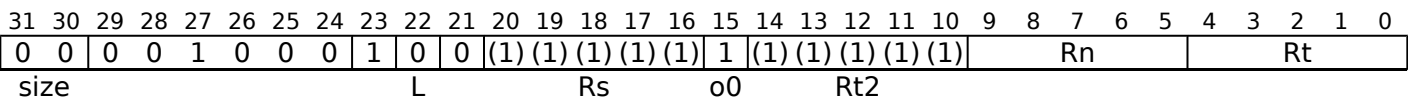
data = X[t];
Mem[address, dbytes, AccType_ORDERED] = data;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

STLRB

Store-Release Register Byte stores a byte from a 32-bit register to a memory location. The instruction also has memory ordering semantics as described in *Load-Acquire, Store-Release*. For information about memory accesses, see *Load/Store addressing modes*.



STLRB <Wt>, [<Xn|SP>{, #0}]

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Operation

```
bits(64) address;
bits(8) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = X[t];
Mem[address, 1, AccType_ORDERED] = data;
```

Operational information

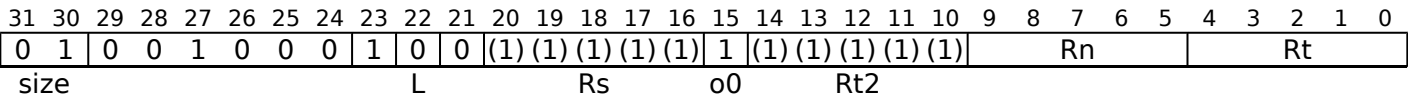
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

STLRH

Store-Release Register Halfword stores a halfword from a 32-bit register to a memory location. The instruction also has memory ordering semantics as described in *Load-Acquire, Store-Release*. For information about memory accesses, see *Load/Store addressing modes*.



```
STLRH <Wt>, [<Xn|SP>{, #0}]
```

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Operation

```
bits(64) address;
bits(16) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = X[t];
Mem[address, 2, AccType_ORDERED] = data;
```

Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41  
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

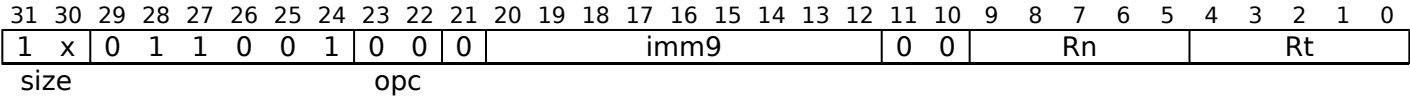
# STLUR

Store-Release Register (unscaled) calculates an address from a base register value and an immediate offset, and stores a 32-bit word or a 64-bit doubleword to the calculated address, from a register.

The instruction has memory ordering semantics as described in *Load-Acquire, Load-AcquirePC, and Store-Release*

For information about memory accesses, see *Load/Store addressing modes*.

## Unscaled offset (FEAT\_LRCPC2)



### 32-bit (size == 10)

```
STLUR <Wt>, [<Xn|SP>{, #<sim>}]
```

### 64-bit (size == 11)

```
STLUR <Xt>, [<Xn|SP>{, #<sim>}]
```

```
integer scale = UInt(size);
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

integer datasize = 8 << scale;
boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(datasize) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = X[t];
Mem[address, datasize DIV 8, AccType_ORDERED] = data;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

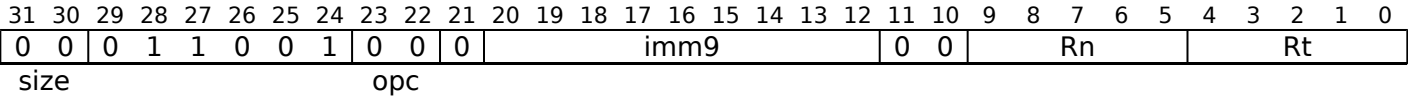
# STLURB

Store-Release Register Byte (unscaled) calculates an address from a base register value and an immediate offset, and stores a byte to the calculated address, from a 32-bit register.

The instruction has memory ordering semantics as described in *Load-Acquire, Load-AcquirePC, and Store-Release*

For information about memory accesses, see *Load/Store addressing modes*.

## Unscaled offset (FEAT\_LRCPC2)



STLURB <Wt>, [<Xn|SP>{, #<sim>}]

```
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(8) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = X[t];
Mem[address, 1, AccType_ORDERED] = data;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

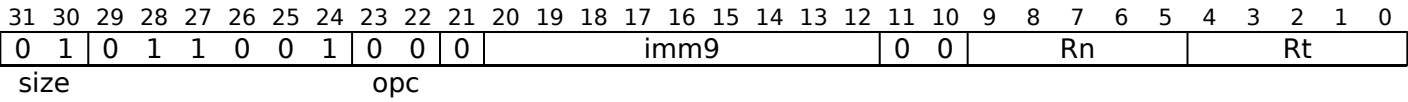
# STLURH

Store-Release Register Halfword (unscaled) calculates an address from a base register value and an immediate offset, and stores a halfword to the calculated address, from a 32-bit register.

The instruction has memory ordering semantics as described in [Load-Acquire, Load-AcquirePC, and Store-Release](#)

For information about memory accesses, see [Load/Store addressing modes](#).

## Unscaled offset (FEAT\_LRCPC2)



STLURH <Wt>, [<Xn|SP>{, #<sim>}]

```
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(16) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = X[t];
Mem[address, 2, AccType_ORDERED] = data;
```

## Operational information

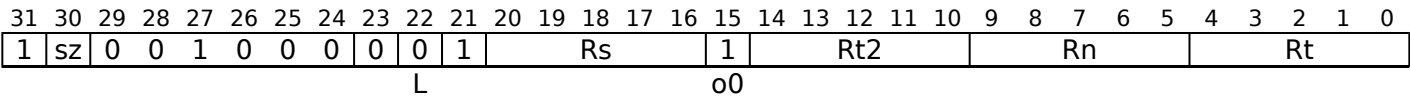
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# STLXP

Store-Release Exclusive Pair of registers stores two 32-bit words or two 64-bit doublewords to a memory location if the PE has exclusive access to the memory address, from two registers, and returns a status value of 0 if the store was successful, or of 1 if no store was performed. See [Synchronization and semaphores](#). For information on single-copy atomicity and alignment requirements, see [Requirements for single-copy atomicity](#) and [Alignment of data accesses](#). If a 64-bit pair Store-Exclusive succeeds, it causes a single-copy atomic update of the 128-bit memory location being updated. The instruction also has memory ordering semantics, as described in [Load-Acquire, Store-Release](#). For information about memory accesses, see [Load/Store addressing modes](#).



## 32-bit (sz == 0)

STLXP <Ws>, <Wt1>, <Wt2>, [<Xn|SP>{, #0}]

## 64-bit (sz == 1)

STLXP <Ws>, <Xt1>, <Xt2>, [<Xn|SP>{, #0}]

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer t2 = UInt(Rt2);    // ignored by load/store single register
integer s = UInt(Rs);      // ignored by all loads and store-release

integer elsize = 32 << UInt(sz);
integer datasize = elsize * 2;
boolean tag_checked = n != 31;

boolean rt_unknown = FALSE;
boolean rn_unknown = FALSE;
if s == t || (s == t2) then
    Constraint c = ConstrainUnpredictable(Unpredictable_DATAOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rt_unknown = TRUE;    // store UNKNOWN value
        when Constraint_NONE     rt_unknown = FALSE;  // store original value
        when Constraint_UNDEF     UNDEFINED;
        when Constraint_NOP       EndOfInstruction();
if s == n && n != 31 then
    Constraint c = ConstrainUnpredictable(Unpredictable_BASEOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rn_unknown = TRUE;    // address is UNKNOWN
        when Constraint_NONE     rn_unknown = FALSE;  // address is original base
        when Constraint_UNDEF     UNDEFINED;
        when Constraint_NOP       EndOfInstruction();
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [STLXP](#).

## Assembler Symbols

- <Ws>

Is the 32-bit name of the general-purpose register into which the status result of the store exclusive is written, encoded in the "Rs" field. The value returned is:  

0

If the operation updates memory.

1

If the operation fails to update memory.
- <Xt1>

Is the 64-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.



- <Xt2> Is the 64-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
- <Wt1> Is the 32-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
- <Wt2> Is the 32-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

#### Aborts and alignment

If a synchronous Data Abort exception is generated by the execution of this instruction:

- Memory is not updated.
- <Ws> is not updated.

Accessing an address that is not aligned to the size of the data being accessed causes an Alignment fault Data Abort exception to be generated, subject to the following rules:

- If AArch64.ExclusiveMonitorsPass() returns TRUE, the exception is generated.
- Otherwise, it is IMPLEMENTATION DEFINED whether the exception is generated.

If AArch64.ExclusiveMonitorsPass() returns FALSE and the memory address, if accessed, would generate a synchronous Data Abort exception, it is IMPLEMENTATION DEFINED whether the exception is generated.

## Operation

```
bits(64) address;
bits(datasize) data;
constant integer dbytes = datasize DIV 8;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
elseif rn_unknown then
    address = bits(64) UNKNOWN;
else
    address = X[n];

if rt_unknown then
    data = bits(datasize) UNKNOWN;
else
    bits(datasize DIV 2) el1 = X[t];
    bits(datasize DIV 2) el2 = X[t2];
    data = if BigEndian(AccType_ORDEREDATOMIC) then el1:el2 else el2:el1;
bit status = '1';
// Check whether the Exclusives monitors are set to include the
// physical memory locations corresponding to virtual address
// range [address, address+dbytes-1].
if AArch64.ExclusiveMonitorsPass(address, dbytes) then
    // This atomic write will be rejected if it does not refer
    // to the same physical locations after address translation.
    Mem[address, dbytes, AccType_ORDEREDATOMIC] = data;
    status = ExclusiveMonitorsStatus();
X[s] = ZeroExtend(status, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## STLXR

Store-Release Exclusive Register stores a 32-bit word or a 64-bit doubleword to memory if the PE has exclusive access to the memory address, from two registers, and returns a status value of 0 if the store was successful, or of 1 if no store was performed. See [Synchronization and semaphores](#). The memory access is atomic. The instruction also has memory ordering semantics as described in [Load-Acquire, Store-Release](#). For information about memory accesses see [Load/Store addressing modes](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	0	0	1	0	0	0	0	0	0					Rs	1	(1)	(1)	(1)	(1)	(1)									Rt	
size								L								o0		Rt2													

### 32-bit (size == 10)

STLXR <Ws>, <Wt>, [<Xn|SP>{, #0}]

### 64-bit (size == 11)

STLXR <Ws>, <Xt>, [<Xn|SP>{, #0}]

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer s = UInt(Rs);    // ignored by all loads and store-release

integer elsize = 8 << UInt(size);
boolean tag_checked = n != 31;

boolean rt_unknown = FALSE;
boolean rn_unknown = FALSE;
if s == t then
    Constraint c = ConstrainUnpredictable(Unpredictable_DATAOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rt_unknown = TRUE;    // store UNKNOWN value
        when Constraint_NONE     rt_unknown = FALSE;    // store original value
        when Constraint_UNDEF     UNDEFINED;
        when Constraint_NOP       EndOfInstruction();
if s == n && n != 31 then
    Constraint c = ConstrainUnpredictable(Unpredictable_BASEOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rn_unknown = TRUE;    // address is UNKNOWN
        when Constraint_NONE     rn_unknown = FALSE;    // address is original base
        when Constraint_UNDEF     UNDEFINED;
        when Constraint_NOP       EndOfInstruction();
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [STLXR](#).

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register into which the status result of the store exclusive is written, encoded in the "Rs" field. The value returned is:
- 0 If the operation updates memory.
  - 1 If the operation fails to update memory.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Aborts and alignment

If a synchronous Data Abort exception is generated by the execution of this instruction:

- Memory is not updated.
- <Ws> is not updated.

Accessing an address that is not aligned to the size of the data being accessed causes an Alignment fault Data Abort exception to be generated, subject to the following rules:

- If `AArch64.ExclusiveMonitorsPass()` returns `TRUE`, the exception is generated.
- Otherwise, it is IMPLEMENTATION DEFINED whether the exception is generated.

If `AArch64.ExclusiveMonitorsPass()` returns `FALSE` and the memory address, if accessed, would generate a synchronous Data Abort exception, it is IMPLEMENTATION DEFINED whether the exception is generated.

## Operation

```
bits(64) address;
bits(elsize) data;
constant integer dbytes = elsize DIV 8;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
elseif rn_unknown then
    address = bits(64) UNKNOWN;
else
    address = X[n];

if rt_unknown then
    data = bits(elsize) UNKNOWN;
else
    data = X[t];

bit status = '1';
// Check whether the Exclusives monitors are set to include the
// physical memory locations corresponding to virtual address
// range [address, address+dbytes-1].
if AArch64.ExclusiveMonitorsPass(address, dbytes) then
    // This atomic write will be rejected if it does not refer
    // to the same physical locations after address translation.
    Mem[address, dbytes, AccType_ORDEREDATOMIC] = data;
    status = ExclusiveMonitorsStatus();
X[s] = ZeroExtend(status, 32);
```

## Operational information

If `PSTATE.DIT` is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## STLXRB

Store-Release Exclusive Register Byte stores a byte from a 32-bit register to memory if the PE has exclusive access to the memory address, and returns a status value of 0 if the store was successful, or of 1 if no store was performed. See [Synchronization and semaphores](#). The memory access is atomic. The instruction also has memory ordering semantics as described in [Load-Acquire, Store-Release](#). For information about memory accesses see [Load/Store addressing modes](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	1	0	0	0	0	0	0	Rs				1	(1)	(1)	(1)	(1)	(1)	Rn					Rt					
size								L				o0				Rt2															

**STLXRB** *<Ws>*, *<Wt>*, [*<Xn|SP>*{, #0}]

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer s = UInt(Rs);    // ignored by all loads and store-release

boolean tag_checked = n != 31;

boolean rt_unknown = FALSE;
boolean rn_unknown = FALSE;
if s == t then
    Constraint c = ConstrainUnpredictable(Unpredictable_DATAOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rt_unknown = TRUE;    // store UNKNOWN value
        when Constraint_NONE     rt_unknown = FALSE;   // store original value
        when Constraint_UNDEF     UNDEFINED;
        when Constraint_NOP       EndOfInstruction();
if s == n && n != 31 then
    Constraint c = ConstrainUnpredictable(Unpredictable_BASEOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rn_unknown = TRUE;    // address is UNKNOWN
        when Constraint_NONE     rn_unknown = FALSE;   // address is original base
        when Constraint_UNDEF     UNDEFINED;
        when Constraint_NOP       EndOfInstruction();
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [STLXRB](#).

### Assembler Symbols

- <Ws>* Is the 32-bit name of the general-purpose register into which the status result of the store exclusive is written, encoded in the "Rs" field. The value returned is:
- 0** If the operation updates memory.
  - 1** If the operation fails to update memory.

*<Wt>* Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.

*<Xn|SP>* Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

#### Aborts

If a synchronous Data Abort exception is generated by the execution of this instruction:

- Memory is not updated.
- *<Ws>* is not updated.

If AArch64.ExclusiveMonitorsPass() returns FALSE and the memory address, if accessed, would generate a synchronous Data Abort exception, it is IMPLEMENTATION DEFINED whether the exception is generated.

## Operation

```
bits(64) address;
bits(8) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
elsif rn_unknown then
    address = bits(64) UNKNOWN;
else
    address = X[n];

if rt_unknown then
    data = bits(8) UNKNOWN;
else
    data = X[t];

bit status = '1';
// Check whether the Exclusives monitors are set to include the
// physical memory locations corresponding to virtual address
// range [address, address+dbytes-1].
if AAarch64.ExclusiveMonitorsPass(address, 1) then
    // This atomic write will be rejected if it does not refer
    // to the same physical locations after address translation.
    Mem[address, 1, AccType_ORDEREDATOMIC] = data;
    status = ExclusiveMonitorsStatus();
X[s] = ZeroExtend(status, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## STLXRH

Store-Release Exclusive Register Halfword stores a halfword from a 32-bit register to memory if the PE has exclusive access to the memory address, and returns a status value of 0 if the store was successful, or of 1 if no store was performed. See [Synchronization and semaphores](#). The memory access is atomic. The instruction also has memory ordering semantics as described in [Load-Acquire, Store-Release](#). For information about memory accesses see [Load/Store addressing modes](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	1	0	0	0	0	0	0	Rs				1	(1)	(1)	(1)	(1)	(1)	Rn				Rt						
size								L				o0				Rt2															

**STLXRH** <Ws>, <Wt>, [<Xn|SP>{, #0}]

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer s = UInt(Rs);    // ignored by all loads and store-release

boolean tag_checked = n != 31;

boolean rt_unknown = FALSE;
boolean rn_unknown = FALSE;
if s == t then
    Constraint c = ConstrainUnpredictable(Unpredictable_DATAOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rt_unknown = TRUE;    // store UNKNOWN value
        when Constraint_NONE     rt_unknown = FALSE;   // store original value
        when Constraint_UNDEF     UNDEFINED;
        when Constraint_NOP       EndOfInstruction();
if s == n && n != 31 then
    Constraint c = ConstrainUnpredictable(Unpredictable_BASEOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rn_unknown = TRUE;    // address is UNKNOWN
        when Constraint_NONE     rn_unknown = FALSE;   // address is original base
        when Constraint_UNDEF     UNDEFINED;
        when Constraint_NOP       EndOfInstruction();
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [STLXRH](#).

## Assembler Symbols

<Ws> Is the 32-bit name of the general-purpose register into which the status result of the store exclusive is written, encoded in the "Rs" field. The value returned is:

**0** If the operation updates memory.

**1** If the operation fails to update memory.

<Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.

<Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

### Aborts and alignment

If a synchronous Data Abort exception is generated by the execution of this instruction:

- Memory is not updated.
- <Ws> is not updated.

A non halfword-aligned memory address causes an Alignment fault Data Abort exception to be generated, subject to the following rules:

- If AArch64.ExclusiveMonitorsPass() returns TRUE, the exception is generated.
- Otherwise, it is IMPLEMENTATION DEFINED whether the exception is generated.

If `AArch64.ExclusiveMonitorsPass()` returns `FALSE` and the memory address, if accessed, would generate a synchronous Data Abort exception, it is IMPLEMENTATION DEFINED whether the exception is generated.

## Operation

```
bits(64) address;
bits(16) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
elsif rn_unknown then
    address = bits(64) UNKNOWN;
else
    address = X[n];

if rt_unknown then
    data = bits(16) UNKNOWN;
else
    data = X[t];

bit status = '1';
// Check whether the Exclusives monitors are set to include the
// physical memory locations corresponding to virtual address
// range [address, address+dbytes-1].
if AArch64.ExclusiveMonitorsPass(address, 2) then
    // This atomic write will be rejected if it does not refer
    // to the same physical locations after address translation.
    Mem[address, 2, AccType_ORDEREDATOMIC] = data;
    status = ExclusiveMonitorsStatus();
X[s] = ZeroExtend(status, 32);
```

## Operational information

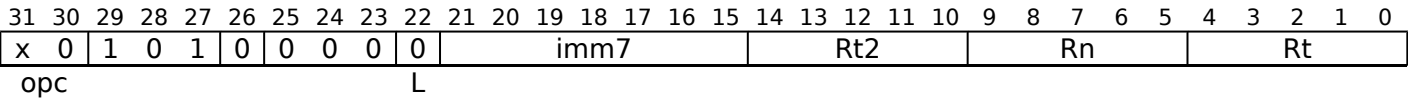
If `PSTATE.DIT` is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# STNP

Store Pair of Registers, with non-temporal hint, calculates an address from a base register value and an immediate offset, and stores two 32-bit words or two 64-bit doublewords to the calculated address, from two registers. For information about memory accesses, see [Load/Store addressing modes](#). For information about Non-temporal pair instructions, see [Load/Store Non-temporal pair](#).



## 32-bit (opc == 00)

STNP <Wt1>, <Wt2>, [<Xn|SP>{, #<imm>}]

## 64-bit (opc == 10)

STNP <Xt1>, <Xt2>, [<Xn|SP>{, #<imm>}]

// Empty.

## Assembler Symbols

- <Wt1> Is the 32-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
- <Wt2> Is the 32-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
- <Xt1> Is the 64-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt2> Is the 64-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> For the 32-bit variant: is the optional signed immediate byte offset, a multiple of 4 in the range -256 to 252, defaulting to 0 and encoded in the "imm7" field as <imm>/4.  
For the 64-bit variant: is the optional signed immediate byte offset, a multiple of 8 in the range -512 to 504, defaulting to 0 and encoded in the "imm7" field as <imm>/8.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer t2 = UInt(Rt2);
if opc<0> == '1' then UNDEFINED;
integer scale = 2 + UInt(opc<1>);
integer datasize = 8 << scale;
bits(64) offset = LSL(SignExtend(imm7, 64), scale);
boolean tag_checked = n != 31;
```



## Operation

```
bits(64) address;
bits(datasize) data1;
bits(datasize) data2;
constant integer dbytes = datasize DIV 8;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data1 = X[t];
data2 = X[t2];
Mem[address, dbytes, AccType_STREAM] = data1;
Mem[address+dbytes, dbytes, AccType_STREAM] = data2;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# STP

Store Pair of Registers calculates an address from a base register value and an immediate offset, and stores two 32-bit words or two 64-bit doublewords to the calculated address, from two registers. For information about memory accesses, see [Load/Store addressing modes](#).

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Signed offset](#)

## Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
x	0	1	0	1	0	0	0	1	0	imm7							Rt2				Rn				Rt						
opc										L																					

### 32-bit (opc == 00)

STP <Wt1>, <Wt2>, [<Xn|SP>], #<imm>

### 64-bit (opc == 10)

STP <Xt1>, <Xt2>, [<Xn|SP>], #<imm>

```
boolean wback = TRUE;
boolean postindex = TRUE;
```

## Pre-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
x	0	1	0	1	0	0	1	1	0	imm7							Rt2				Rn				Rt						
opc										L																					

### 32-bit (opc == 00)

STP <Wt1>, <Wt2>, [<Xn|SP>, #<imm>]!

### 64-bit (opc == 10)

STP <Xt1>, <Xt2>, [<Xn|SP>, #<imm>]!

```
boolean wback = TRUE;
boolean postindex = FALSE;
```

## Signed offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
x	0	1	0	1	0	0	1	0	0	imm7							Rt2				Rn				Rt						
opc										L																					

### 32-bit (opc == 00)

STP <Wt1>, <Wt2>, [<Xn|SP>{, #<imm>}]

### 64-bit (opc == 10)

STP <Xt1>, <Xt2>, [<Xn|SP>{, #<imm>}]

```
boolean wback = FALSE;
boolean postindex = FALSE;
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [STP](#).

## Assembler Symbols

<Wt1>	Is the 32-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
<Wt2>	Is the 32-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
<Xt1>	Is the 64-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
<Xt2>	Is the 64-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<imm>	<p>For the 32-bit post-index and 32-bit pre-index variant: is the signed immediate byte offset, a multiple of 4 in the range -256 to 252, encoded in the "imm7" field as &lt;imm&gt;/4.</p> <p>For the 32-bit signed offset variant: is the optional signed immediate byte offset, a multiple of 4 in the range -256 to 252, defaulting to 0 and encoded in the "imm7" field as &lt;imm&gt;/4.</p> <p>For the 64-bit post-index and 64-bit pre-index variant: is the signed immediate byte offset, a multiple of 8 in the range -512 to 504, encoded in the "imm7" field as &lt;imm&gt;/8.</p> <p>For the 64-bit signed offset variant: is the optional signed immediate byte offset, a multiple of 8 in the range -512 to 504, defaulting to 0 and encoded in the "imm7" field as &lt;imm&gt;/8.</p>

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer t2 = UInt(Rt2);
if L:opc<0> == '01' || opc == '11' then UNDEFINED;
integer scale = 2 + UInt(opc<1>);
integer datasize = 8 << scale;
bits(64) offset = LSL(SignExtend(imm7, 64), scale);
boolean tag_checked = wback || n != 31;

boolean rt_unknown = FALSE;

if wback && (t == n || t2 == n) && n != 31 then
    Constraint c = ConstrainUnpredictable(Unpredictable_WBOVERLAPST);
    assert c IN {Constraint_NONE, Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_NONE      rt_unknown = FALSE;      // value stored is pre-writeback
        when Constraint_UNKNOWN    rt_unknown = TRUE;       // value stored is UNKNOWN
        when Constraint_UNDEF      UNDEFINED;
        when Constraint_NOP        EndOfInstruction();
```

## Operation

```
bits(64) address;
bits(datasize) data1;
bits(datasize) data2;
constant integer dbytes = datasize DIV 8;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

if rt_unknown && t == n then
    data1 = bits(datasize) UNKNOWN;
else
    data1 = X[t];
if rt_unknown && t2 == n then
    data2 = bits(datasize) UNKNOWN;
else
    data2 = X[t2];
if HaveLSE2Ext() then
    bits(2*datasize) full_data;
    if BigEndian(AccType_NORMAL) then
        full_data = data1:data2;
    else
        full_data = data2:data1;
    Mem[address, 2*dbytes, AccType_NORMAL, TRUE] = full_data;
else
    Mem[address, dbytes, AccType_NORMAL] = data1;
    Mem[address+dbytes, dbytes, AccType_NORMAL] = data2;

if wback then
    if postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

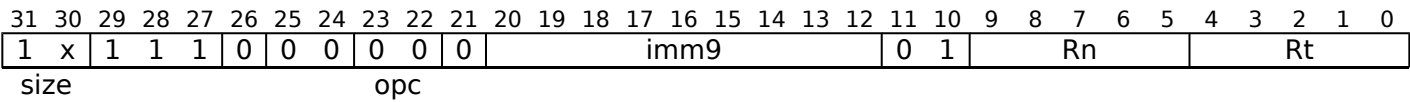
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# STR (immediate)

Store Register (immediate) stores a word or a doubleword from a register to memory. The address that is used for the store is calculated from a base register and an immediate offset. For information about memory accesses, see [Load/Store addressing modes](#).

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Unsigned offset](#)

## Post-index



### 32-bit (size == 10)

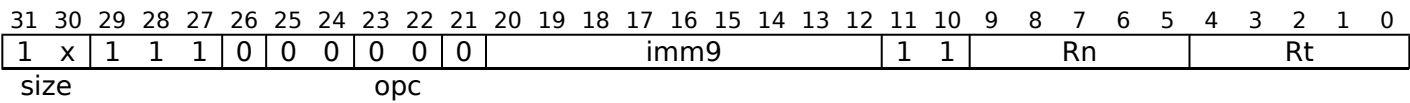
STR <Wt>, [<Xn|SP>], #<sim>

### 64-bit (size == 11)

STR <Xt>, [<Xn|SP>], #<sim>

```
boolean wback = TRUE;
boolean postindex = TRUE;
integer scale = UInt(size);
bits(64) offset = SignExtend(imm9, 64);
```

## Pre-index



### 32-bit (size == 10)

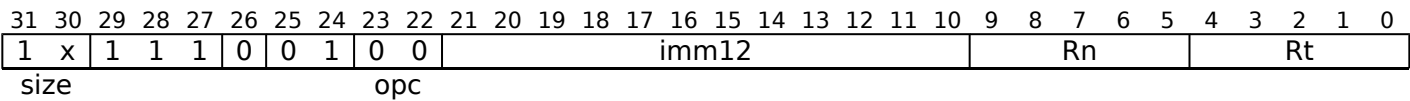
STR <Wt>, [<Xn|SP>, #<sim>]!

### 64-bit (size == 11)

STR <Xt>, [<Xn|SP>, #<sim>]!

```
boolean wback = TRUE;
boolean postindex = FALSE;
integer scale = UInt(size);
bits(64) offset = SignExtend(imm9, 64);
```

## Unsigned offset



### 32-bit (size == 10)

```
STR <Wt>, [<Xn|SP>{, #<pimm>}]
```

### 64-bit (size == 11)

```
STR <Xt>, [<Xn|SP>{, #<pimm>}]
```

```
boolean wback = FALSE;
boolean postindex = FALSE;
integer scale = UInt(size);
bits(64) offset = LSL(ZeroExtend(imm12, 64), scale);
```

## Assembler Symbols

<Wt>	Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
<Xt>	Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<sim>	Is the signed immediate byte offset, in the range -256 to 255, encoded in the "imm9" field.
<pimm>	For the 32-bit variant: is the optional positive immediate byte offset, a multiple of 4 in the range 0 to 16380, defaulting to 0 and encoded in the "imm12" field as <pimm>/4. For the 64-bit variant: is the optional positive immediate byte offset, a multiple of 8 in the range 0 to 32760, defaulting to 0 and encoded in the "imm12" field as <pimm>/8.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

integer datasize = 8 << scale;
boolean tag_checked = wback || n != 31;

boolean rt_unknown = FALSE;

if wback && n == t && n != 31 then
  c = ConstrainUnpredictable(Unpredictable_WBOVERLAPST);
  assert c IN {Constraint_NONE, Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
  case c of
    when Constraint_NONE    rt_unknown = FALSE;    // value stored is original value
    when Constraint_UNKNOWN  rt_unknown = TRUE;     // value stored is UNKNOWN
    when Constraint_UNDEF    UNDEFINED;
    when Constraint_NOP      EndOfInstruction();
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(datasize) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

if rt_unknown then
    data = bits(datasize) UNKNOWN;
else
    data = X[t];
Mem[address, datasize DIV 8, AccType_NORMAL] = data;

if wback then
    if postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

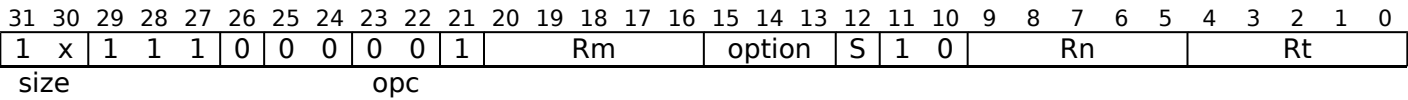
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## STR (register)

Store Register (register) calculates an address from a base register value and an offset register value, and stores a 32-bit word or a 64-bit doubleword to the calculated address, from a register. For information about memory accesses, see [Load/Store addressing modes](#).

The instruction uses an offset addressing mode, that calculates the address used for the memory access from a base register value and an offset register value. The offset can be optionally shifted and extended.



### 32-bit (size == 10)

```
STR <Wt>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]
```

### 64-bit (size == 11)

```
STR <Xt>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]
```

```
integer scale = UInt(size);
if option<1> == '0' then UNDEFINED; // sub-word index
ExtendType extend_type = DecodeRegExtend(option);
integer shift = if S == '1' then scale else 0;
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Wm> When option<0> is set to 0, is the 32-bit name of the general-purpose index register, encoded in the "Rm" field.
- <Xm> When option<0> is set to 1, is the 64-bit name of the general-purpose index register, encoded in the "Rm" field.
- <extend> Is the index extend/shift specifier, defaulting to LSL, and which must be omitted for the LSL option when <amount> is omitted. encoded in "option":

option	<extend>
010	UXTW
011	LSL
110	SXTW
111	SCTX

- <amount> For the 32-bit variant: is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in "S":

S	<amount>
0	#0
1	#2

- For the 64-bit variant: is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in "S":

S	<amount>
0	#0
1	#3



## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer m = UInt(Rm);

integer datasize = 8 << scale;
```

## Operation

```
bits(64) offset = ExtendReg(m, extend_type, shift);
if HaveMTE2Ext() then
    SetTagCheckedInstruction(TRUE);

bits(64) address;
bits(datasize) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = X[t];
Mem[address, datasize DIV 8, AccType_NORMAL] = data;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

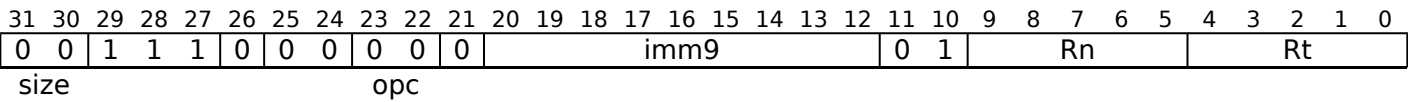
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# STRB (immediate)

Store Register Byte (immediate) stores the least significant byte of a 32-bit register to memory. The address that is used for the store is calculated from a base register and an immediate offset. For information about memory accesses, see [Load/Store addressing modes](#).

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Unsigned offset](#)

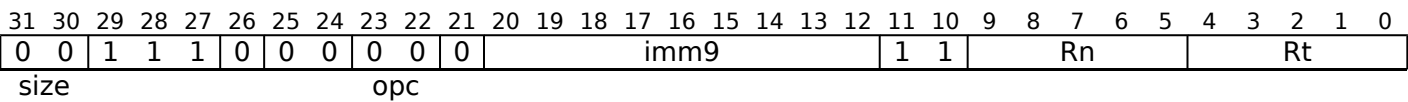
## Post-index



STRB <Wt>, [<Xn|SP>], #<sim>

```
boolean wback = TRUE;
boolean postindex = TRUE;
bits(64) offset = SignExtend(imm9, 64);
```

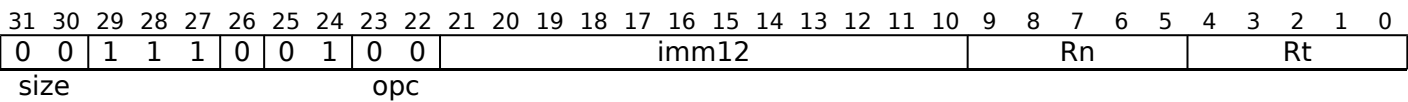
## Pre-index



STRB <Wt>, [<Xn|SP>, #<sim>]!

```
boolean wback = TRUE;
boolean postindex = FALSE;
bits(64) offset = SignExtend(imm9, 64);
```

## Unsigned offset



STRB <Wt>, [<Xn|SP>{, #<pimm>}]

```
boolean wback = FALSE;
boolean postindex = FALSE;
bits(64) offset = LSL(ZeroExtend(imm12, 64), 0);
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [STRB \(immediate\)](#).

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the signed immediate byte offset, in the range -256 to 255, encoded in the "imm9" field.
- <pimm> Is the optional positive immediate byte offset, in the range 0 to 4095, defaulting to 0 and encoded in the "imm12" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = wback || n != 31;

boolean rt_unknown = FALSE;

if wback && n == t && n != 31 then
    c = ConstrainUnpredictable(Unpredictable_WBOVERLAPST);
    assert c IN {Constraint_NONE, Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_NONE    rt_unknown = FALSE;    // value stored is original value
        when Constraint_UNKNOWN  rt_unknown = TRUE;     // value stored is UNKNOWN
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(8) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

if rt_unknown then
    data = bits(8) UNKNOWN;
else
    data = X[t];
Mem[address, 1, AccType_NORMAL] = data;

if wback then
    if postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## STRB (register)

Store Register Byte (register) calculates an address from a base register value and an offset register value, and stores a byte from a 32-bit register to the calculated address. For information about memory accesses, see [Load/Store addressing modes](#).

The instruction uses an offset addressing mode, that calculates the address used for the memory access from a base register value and an offset register value. The offset can be optionally shifted and extended.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	0	0	1	Rm				option			S	1	0	Rn				Rt						
size											opc																				

### Extended register (option != 011)

STRB <Wt>, [<Xn|SP>, (<Wm>|<Xm>), <extend> {<amount>}]

### Shifted register (option == 011)

STRB <Wt>, [<Xn|SP>, <Xm>{, LSL <amount>}]

```
if option<1> == '0' then UNDEFINED; // sub-word index
ExtendType extend_type = DecodeRegExtend(option);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Wm> When option<0> is set to 0, is the 32-bit name of the general-purpose index register, encoded in the "Rm" field.
- <Xm> When option<0> is set to 1, is the 64-bit name of the general-purpose index register, encoded in the "Rm" field.
- <extend> Is the index extend specifier, encoded in "option":

option	<extend>
010	UXTW
110	SXTW
111	SCTX

<amount> Is the index shift amount, it must be #0, encoded in "S" as 0 if omitted, or as 1 if present.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer m = UInt(Rm);
```

## Operation

```
bits(64) offset = ExtendReg(m, extend_type, 0);
if HaveMTE2Ext() then
    SetTagCheckedInstruction(TRUE);

bits(64) address;
bits(8) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = X[t];
Mem[address, 1, AccType_NORMAL] = data;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# STRH (immediate)

Store Register Halfword (immediate) stores the least significant halfword of a 32-bit register to memory. The address that is used for the store is calculated from a base register and an immediate offset. For information about memory accesses, see [Load/Store addressing modes](#).

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Unsigned offset](#)

## Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	0	0	0	imm9									0	1	Rn				Rt					
size										opc																					

STRH <Wt>, [<Xn|SP>], #<sim>

```
boolean wback = TRUE;
boolean postindex = TRUE;
bits(64) offset = SignExtend(imm9, 64);
```

## Pre-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	0	0	0	imm9									1	1	Rn				Rt					
size										opc																					

STRH <Wt>, [<Xn|SP>, #<sim>]!

```
boolean wback = TRUE;
boolean postindex = FALSE;
bits(64) offset = SignExtend(imm9, 64);
```

## Unsigned offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	1	0	0	imm12											Rn				Rt						
size										opc																					

STRH <Wt>, [<Xn|SP>{, #<pimm>}]

```
boolean wback = FALSE;
boolean postindex = FALSE;
bits(64) offset = LSL(ZeroExtend(imm12, 64), 1);
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [STRH \(immediate\)](#).

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the signed immediate byte offset, in the range -256 to 255, encoded in the "imm9" field.
- <pimm> Is the optional positive immediate byte offset, a multiple of 2 in the range 0 to 8190, defaulting to 0 and encoded in the "imm12" field as <pimm>/2.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = wback || n != 31;

boolean rt_unknown = FALSE;

if wback && n == t && n != 31 then
    c = ConstrainUnpredictable(Unpredictable_WBOVERLAPST);
    assert c IN {Constraint_NONE, Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_NONE      rt_unknown = FALSE;    // value stored is original value
        when Constraint_UNKNOWN    rt_unknown = TRUE;     // value stored is UNKNOWN
        when Constraint_UNDEF      UNDEFINED;
        when Constraint_NOP        EndOfInstruction();
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(16) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

if rt_unknown then
    data = bits(16) UNKNOWN;
else
    data = X[t];
Mem[address, 2, AccType_NORMAL] = data;

if wback then
    if postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# STRH (register)

Store Register Halfword (register) calculates an address from a base register value and an offset register value, and stores a halfword from a 32-bit register to the calculated address. For information about memory accesses, see [Load/Store addressing modes](#).

The instruction uses an offset addressing mode, that calculates the address used for the memory access from a base register value and an offset register value. The offset can be optionally shifted and extended.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	0	0	1	Rm				option		S	1	0	Rn				Rt							
size										opc																					

STRH <Wt>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]

```
if option<1> == '0' then UNDEFINED;    // sub-word index
ExtendType extend_type = DecodeRegExtend(option);
integer shift = if S == '1' then 1 else 0;
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Wm> When option<0> is set to 0, is the 32-bit name of the general-purpose index register, encoded in the "Rm" field.
- <Xm> When option<0> is set to 1, is the 64-bit name of the general-purpose index register, encoded in the "Rm" field.
- <extend> Is the index extend/shift specifier, defaulting to LSL, and which must be omitted for the LSL option when <amount> is omitted. encoded in "option":

option	<extend>
010	UXTW
011	LSL
110	SXTW
111	SCTX

<amount> Is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in "S":

S	<amount>
0	#0
1	#1

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer m = UInt(Rm);
```



## Operation

```
bits(64) offset = ExtendReg(m, extend_type, shift);
if HaveMTE2Ext() then
    SetTagCheckedInstruction(TRUE);

bits(64) address;
bits(16) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = X[t];
Mem[address, 2, AccType_NORMAL] = data;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# STSET, STSETL

Atomic bit set on word or doubleword in memory, without return, atomically loads a 32-bit word or 64-bit doubleword from memory, performs a bitwise OR with the value held in a register on it, and stores the result back to memory.

- STSET does not have release semantics.
  - STSETL stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.
- For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDSET, LDSETA, LDSETAL, LDSETL](#). This means:

- The encodings in this description are named to match the encodings of [LDSET, LDSETA, LDSETAL, LDSETL](#).
- The description of [LDSET, LDSETA, LDSETAL, LDSETL](#) gives the operational pseudocode for this instruction.

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	0	0	R	1			Rs			0	0	1	1	0	0			Rn			1	1	1	1	1
size								A								opc								Rt							

### 32-bit LDSET alias (size == 10 && R == 0)

STSET <Ws>, [<Xn|SP>]

is equivalent to

LDSET <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### 32-bit LDSETL alias (size == 10 && R == 1)

STSETL <Ws>, [<Xn|SP>]

is equivalent to

LDSETL <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### 64-bit LDSET alias (size == 11 && R == 0)

STSET <Xs>, [<Xn|SP>]

is equivalent to

LDSET <Xs>, XZR, [<Xn|SP>]

and is always the preferred disassembly.

### 64-bit LDSETL alias (size == 11 && R == 1)

STSETL <Xs>, [<Xn|SP>]

is equivalent to

LDSETL <Xs>, XZR, [<Xn|SP>]

and is always the preferred disassembly.

## Assembler Symbols

<Ws>	Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xs>	Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDSET](#), [LDSETA](#), [LDSETAL](#), [LDSETL](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# STSETB, STSETLB

Atomic bit set on byte in memory, without return, atomically loads an 8-bit byte from memory, performs a bitwise OR with the value held in a register on it, and stores the result back to memory.

- STSETB does not have release semantics.
  - STSETLB stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.
- For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDSETB, LDSETAB, LDSETALB, LDSETLB](#). This means:

- The encodings in this description are named to match the encodings of [LDSETB, LDSETAB, LDSETALB, LDSETLB](#).
- The description of [LDSETB, LDSETAB, LDSETALB, LDSETLB](#) gives the operational pseudocode for this instruction.

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	0	1	1	1	0	0	0	0	R	1	Rs				0	0	1	1	0	0	Rn				1	1	1	1	1			
size								A				opc								Rt												

### No memory ordering (R == 0)

STSETB <Ws>, [<Xn|SP>]

is equivalent to

[LDSETB](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### Release (R == 1)

STSETLB <Ws>, [<Xn|SP>]

is equivalent to

[LDSETLB](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDSETB, LDSETAB, LDSETALB, LDSETLB](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

# STSETH, STSETLH

Atomic bit set on halfword in memory, without return, atomically loads a 16-bit halfword from memory, performs a bitwise OR with the value held in a register on it, and stores the result back to memory.

- STSETH does not have release semantics.
  - STSETLH stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.
- For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDSETH, LDSETAH, LDSETALH, LDSETLH](#). This means:

- The encodings in this description are named to match the encodings of [LDSETH, LDSETAH, LDSETALH, LDSETLH](#).
- The description of [LDSETH, LDSETAH, LDSETALH, LDSETLH](#) gives the operational pseudocode for this instruction.

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	0	R	1	Rs				0	0	1	1	0	0	Rn				1	1	1	1	1		
size								A				opc								Rt											

### No memory ordering (R == 0)

STSETH *<Ws>*, [*<Xn|SP>*]  
is equivalent to  
[LDSETH](#) *<Ws>*, WZR, [*<Xn|SP>*]  
and is always the preferred disassembly.

### Release (R == 1)

STSETLH *<Ws>*, [*<Xn|SP>*]  
is equivalent to  
[LDSETLH](#) *<Ws>*, WZR, [*<Xn|SP>*]  
and is always the preferred disassembly.

## Assembler Symbols

- <Ws>* Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP>* Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDSETH, LDSETAH, LDSETALH, LDSETLH](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

# STSMAX, STSMAXL

Atomic signed maximum on word or doubleword in memory, without return, atomically loads a 32-bit word or 64-bit doubleword from memory, compares it against the value held in a register, and stores the larger value back to memory, treating the values as signed numbers.

- STSMAX does not have release semantics.
- STSMAXL stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDSMAX](#), [LDSMAXA](#), [LDSMAXAL](#), [LDSMAXL](#). This means:

- The encodings in this description are named to match the encodings of [LDSMAX](#), [LDSMAXA](#), [LDSMAXAL](#), [LDSMAXL](#).
- The description of [LDSMAX](#), [LDSMAXA](#), [LDSMAXAL](#), [LDSMAXL](#) gives the operational pseudocode for this instruction.

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	0	0	R	1	Rs				0	1	0	0	0	0	Rn				1	1	1	1	1		
size				A								opc								Rt											

### 32-bit LDSMAX alias (size == 10 && R == 0)

STSMAX *<Ws>*, [*<Xn|SP>*]

is equivalent to

*LDSMAX* *<Ws>*, WZR, [*<Xn|SP>*]

and is always the preferred disassembly.

### 32-bit LDSMAXL alias (size == 10 && R == 1)

STSMAXL *<Ws>*, [*<Xn|SP>*]

is equivalent to

*LDSMAXL* *<Ws>*, WZR, [*<Xn|SP>*]

and is always the preferred disassembly.

### 64-bit LDSMAX alias (size == 11 && R == 0)

STSMAX *<Xs>*, [*<Xn|SP>*]

is equivalent to

*LDSMAX* *<Xs>*, XZR, [*<Xn|SP>*]

and is always the preferred disassembly.

### 64-bit LDSMAXL alias (size == 11 && R == 1)

STSMAXL *<Xs>*, [*<Xn|SP>*]

is equivalent to

*LDSMAXL* *<Xs>*, XZR, [*<Xn|SP>*]

and is always the preferred disassembly.

## Assembler Symbols

<Ws>	Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xs>	Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDSMAX](#), [LDSMAXA](#), [LDSMAXAL](#), [LDSMAXL](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# STSMAXB, STSMAXB

Atomic signed maximum on byte in memory, without return, atomically loads an 8-bit byte from memory, compares it against the value held in a register, and stores the larger value back to memory, treating the values as signed numbers.

- STSMAXB does not have release semantics.
  - STSMAXB stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.
- For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDSMAXB, LDSMAXAB, LDSMAXALB, LDSMAXLB](#). This means:

- The encodings in this description are named to match the encodings of [LDSMAXB, LDSMAXAB, LDSMAXALB, LDSMAXLB](#).
- The description of [LDSMAXB, LDSMAXAB, LDSMAXALB, LDSMAXLB](#) gives the operational pseudocode for this instruction.

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	0	R	1	Rs				0	1	0	0	0	0	Rn				1	1	1	1	1		
size				A								opc										Rt									

### No memory ordering (R == 0)

STSMAXB <Ws>, [<Xn|SP>]

is equivalent to

[LDSMAXB](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### Release (R == 1)

STSMAXB <Ws>, [<Xn|SP>]

is equivalent to

[LDSMAXLB](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDSMAXB, LDSMAXAB, LDSMAXALB, LDSMAXLB](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.



# STSMAXH, STSMAXLH

Atomic signed maximum on halfword in memory, without return, atomically loads a 16-bit halfword from memory, compares it against the value held in a register, and stores the larger value back to memory, treating the values as signed numbers.

- STSMAXH does not have release semantics.
- STSMAXLH stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDSMAXH](#), [LDSMAXAH](#), [LDSMAXALH](#), [LDSMAXLH](#). This means:

- The encodings in this description are named to match the encodings of [LDSMAXH](#), [LDSMAXAH](#), [LDSMAXALH](#), [LDSMAXLH](#).
- The description of [LDSMAXH](#), [LDSMAXAH](#), [LDSMAXALH](#), [LDSMAXLH](#) gives the operational pseudocode for this instruction.

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	0	R	1			Rs			0	1	0	0	0	0			Rn			1	1	1	1	1
size								A				opc												Rt							

### No memory ordering (R == 0)

STSMAXH <Ws>, [<Xn|SP>]

is equivalent to

[LDSMAXH](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### Release (R == 1)

STSMAXLH <Ws>, [<Xn|SP>]

is equivalent to

[LDSMAXLH](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDSMAXH](#), [LDSMAXAH](#), [LDSMAXALH](#), [LDSMAXLH](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# STSMIN, STSMINL

Atomic signed minimum on word or doubleword in memory, without return, atomically loads a 32-bit word or 64-bit doubleword from memory, compares it against the value held in a register, and stores the smaller value back to memory, treating the values as signed numbers.

- STSMIN does not have release semantics.
- STSMINL stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDSMIN](#), [LDSMINA](#), [LDSMINAL](#), [LDSMINL](#). This means:

- The encodings in this description are named to match the encodings of [LDSMIN](#), [LDSMINA](#), [LDSMINAL](#), [LDSMINL](#).
- The description of [LDSMIN](#), [LDSMINA](#), [LDSMINAL](#), [LDSMINL](#) gives the operational pseudocode for this instruction.

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	0	0	R	1	Rs				0	1	0	1	0	0	Rn				1	1	1	1	1		
size				A				opc								Rt															

### 32-bit LDSMIN alias (size == 10 && R == 0)

STSMIN <Ws>, [<Xn|SP>]

is equivalent to

[LDSMIN](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### 32-bit LDSMINL alias (size == 10 && R == 1)

STSMINL <Ws>, [<Xn|SP>]

is equivalent to

[LDSMINL](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### 64-bit LDSMIN alias (size == 11 && R == 0)

STSMIN <Xs>, [<Xn|SP>]

is equivalent to

[LDSMIN](#) <Xs>, XZR, [<Xn|SP>]

and is always the preferred disassembly.

### 64-bit LDSMINL alias (size == 11 && R == 1)

STSMINL <Xs>, [<Xn|SP>]

is equivalent to

[LDSMINL](#) <Xs>, XZR, [<Xn|SP>]

and is always the preferred disassembly.

## Assembler Symbols

<Ws>	Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xs>	Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDSDMIN](#), [LDSDMINA](#), [LDSDMINAL](#), [LDSDMINL](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# STSMINB, STSMINLB

Atomic signed minimum on byte in memory, without return, atomically loads an 8-bit byte from memory, compares it against the value held in a register, and stores the smaller value back to memory, treating the values as signed numbers.

- STSMINB does not have release semantics.
- STSMINLB stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDSMINB](#), [LDSMINAB](#), [LDSMINALB](#), [LDSMINLB](#). This means:

- The encodings in this description are named to match the encodings of [LDSMINB](#), [LDSMINAB](#), [LDSMINALB](#), [LDSMINLB](#).
- The description of [LDSMINB](#), [LDSMINAB](#), [LDSMINALB](#), [LDSMINLB](#) gives the operational pseudocode for this instruction.

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	0	R	1			Rs			0	1	0	1	0	0			Rn			1	1	1	1	1
size								A				opc										Rt									

### No memory ordering (R == 0)

STSMINB <Ws>, [<Xn|SP>]  
is equivalent to  
[LDSMINB](#) <Ws>, WZR, [<Xn|SP>]  
and is always the preferred disassembly.

### Release (R == 1)

STSMINLB <Ws>, [<Xn|SP>]  
is equivalent to  
[LDSMINLB](#) <Ws>, WZR, [<Xn|SP>]  
and is always the preferred disassembly.

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDSMINB](#), [LDSMINAB](#), [LDSMINALB](#), [LDSMINLB](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

# STSMINH, STSMINLH

Atomic signed minimum on halfword in memory, without return, atomically loads a 16-bit halfword from memory, compares it against the value held in a register, and stores the smaller value back to memory, treating the values as signed numbers.

- STSMINH does not have release semantics.
- STSMINLH stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDSMINH](#), [LDSMINAH](#), [LDSMINALH](#), [LDSMINLH](#). This means:

- The encodings in this description are named to match the encodings of [LDSMINH](#), [LDSMINAH](#), [LDSMINALH](#), [LDSMINLH](#).
- The description of [LDSMINH](#), [LDSMINAH](#), [LDSMINALH](#), [LDSMINLH](#) gives the operational pseudocode for this instruction.

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	0	R	1	Rs					0	1	0	1	0	0	Rn					1	1	1	1	1
size					A					opc															Rt						

### No memory ordering (R == 0)

STSMINH <Ws>, [<Xn|SP>]  
is equivalent to  
[LDSMINH](#) <Ws>, WZR, [<Xn|SP>]  
and is always the preferred disassembly.

### Release (R == 1)

STSMINLH <Ws>, [<Xn|SP>]  
is equivalent to  
[LDSMINLH](#) <Ws>, WZR, [<Xn|SP>]  
and is always the preferred disassembly.

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDSMINH](#), [LDSMINAH](#), [LDSMINALH](#), [LDSMINLH](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

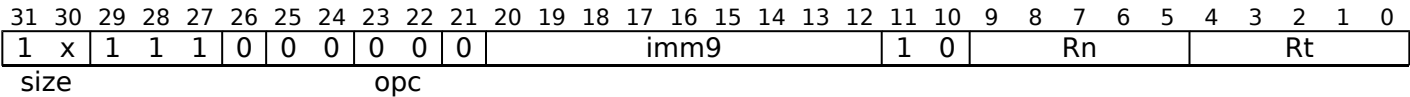
# STTR

Store Register (unprivileged) stores a word or doubleword from a register to memory. The address that is used for the store is calculated from a base register and an immediate offset.

Memory accesses made by the instruction behave as if the instruction was executed at EL0 if the *Effective value* of PSTATE.UAO is 0 and either:

- The instruction is executed at EL1.
- The instruction is executed at EL2 when the *Effective value* of HCR\_EL2.{E2H, TGE} is {1, 1}.

Otherwise, the memory access operates with the restrictions determined by the Exception level at which the instruction is executed. For information about memory accesses, see *Load/Store addressing modes*.



## 32-bit (size == 10)

STTR <Wt>, [<Xn|SP>{, #<sim>}]

## 64-bit (size == 11)

STTR <Xt>, [<Xn|SP>{, #<sim>}]

```
integer scale = UInt(size);
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

unpriv_at_el1 = PSTATE.EL == EL1 && !(EL2Enabled() && HaveNVExt() && HCR_EL2.<NV,NV1> == '11');
unpriv_at_el2 = PSTATE.EL == EL2 && HaveVirtHostExt() && HCR_EL2.<E2H,TGE> == '11';

user_access_override = HaveUA0Ext() && PSTATE.UAO == '1';
if !user_access_override && (unpriv_at_el1 || unpriv_at_el2) then
    acctype = AccType_UNPRIV;
else
    acctype = AccType_NORMAL;

integer datasize = 8 << scale;
boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(datasize) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = X[t];
Mem[address, datasize DIV 8, acctype] = data;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## STTRB

Store Register Byte (unprivileged) stores a byte from a 32-bit register to memory. The address that is used for the store is calculated from a base register and an immediate offset.

Memory accesses made by the instruction behave as if the instruction was executed at EL0 if the *Effective value* of PSTATE.UAO is 0 and either:

- The instruction is executed at EL1.
- The instruction is executed at EL2 when the *Effective value* of *HCR\_EL2*.{E2H, TGE} is {1, 1}.

Otherwise, the memory access operates with the restrictions determined by the Exception level at which the instruction is executed. For information about memory accesses, see *Load/Store addressing modes*.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
0	0	1	1	1	0	0	0	0	0	0	imm9									1	0	Rn				Rt									
size										opc																									

STTRB <Wt>, [<Xn|SP>{, #<sim>}]

```
bits(64) offset = SignExtend(imm9, 64);
```

### Assembler Symbols

<Wt>	Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<sim>	Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

### Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

unpriv_at_el1 = PSTATE.EL == EL1 && !(EL2Enabled() && HaveNVExt() && HCR_EL2.<NV,NV1> == '11');
unpriv_at_el2 = PSTATE.EL == EL2 && HaveVirtHostExt() && HCR_EL2.<E2H,TGE> == '11';

user_access_override = HaveUA0Ext() && PSTATE.UAO == '1';
if !user_access_override && (unpriv_at_el1 || unpriv_at_el2) then
    acctype = AccType_UNPRIV;
else
    acctype = AccType_NORMAL;

boolean tag_checked = n != 31;
```

### Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(8) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = X[t];
Mem[address, 1, acctype] = data;
```



## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## STTRH

Store Register Halfword (unprivileged) stores a halfword from a 32-bit register to memory. The address that is used for the store is calculated from a base register and an immediate offset.

Memory accesses made by the instruction behave as if the instruction was executed at EL0 if the *Effective value* of PSTATE.UAO is 0 and either:

- The instruction is executed at EL1.
- The instruction is executed at EL2 when the *Effective value* of *HCR\_EL2*.{E2H, TGE} is {1, 1}.

Otherwise, the memory access operates with the restrictions determined by the Exception level at which the instruction is executed. For information about memory accesses, see *Load/Store addressing modes*.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	0	0	0	imm9									1	0	Rn				Rt					
size									opc																						

STTRH <Wt>, [<Xn|SP>{, #<sim>}]

```
bits(64) offset = SignExtend(imm9, 64);
```

### Assembler Symbols

<Wt>	Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<sim>	Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

### Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

unpriv_at_el1 = PSTATE.EL == EL1 && !(EL2Enabled() && HaveNVExt() && HCR_EL2.<NV,NV1> == '11');
unpriv_at_el2 = PSTATE.EL == EL2 && HaveVirtHostExt() && HCR_EL2.<E2H,TGE> == '11';

user_access_override = HaveUA0Ext() && PSTATE.UAO == '1';
if !user_access_override && (unpriv_at_el1 || unpriv_at_el2) then
    acctype = AccType_UNPRIV;
else
    acctype = AccType_NORMAL;

boolean tag_checked = n != 31;
```

### Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(16) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = X[t];
Mem[address, 2, acctype] = data;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# STUMAX, STUMAXL

Atomic unsigned maximum on word or doubleword in memory, without return, atomically loads a 32-bit word or 64-bit doubleword from memory, compares it against the value held in a register, and stores the larger value back to memory, treating the values as unsigned numbers.

- STUMAX does not have release semantics.
- STUMAXL stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDUMAX, LDUMAXA, LDUMAXAL, LDUMAXL](#). This means:

- The encodings in this description are named to match the encodings of [LDUMAX, LDUMAXA, LDUMAXAL, LDUMAXL](#).
- The description of [LDUMAX, LDUMAXA, LDUMAXAL, LDUMAXL](#) gives the operational pseudocode for this instruction.

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	0	0	R	1	Rs				0	1	1	0	0	0	Rn				1	1	1	1	1		
size				A								opc												Rt							

### 32-bit LDUMAX alias (size == 10 && R == 0)

STUMAX *<Ws>*, [*<Xn|SP>*]

is equivalent to

*LDUMAX* *<Ws>*, WZR, [*<Xn|SP>*]

and is always the preferred disassembly.

### 32-bit LDUMAXL alias (size == 10 && R == 1)

STUMAXL *<Ws>*, [*<Xn|SP>*]

is equivalent to

*LDUMAXL* *<Ws>*, WZR, [*<Xn|SP>*]

and is always the preferred disassembly.

### 64-bit LDUMAX alias (size == 11 && R == 0)

STUMAX *<Xs>*, [*<Xn|SP>*]

is equivalent to

*LDUMAX* *<Xs>*, XZR, [*<Xn|SP>*]

and is always the preferred disassembly.

### 64-bit LDUMAXL alias (size == 11 && R == 1)

STUMAXL *<Xs>*, [*<Xn|SP>*]

is equivalent to

*LDUMAXL* *<Xs>*, XZR, [*<Xn|SP>*]

and is always the preferred disassembly.

## Assembler Symbols

<Ws>	Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xs>	Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDUMAX, LDUMAXA, LDUMAXAL, LDUMAXL](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# STUMAXB, STUMAXB

Atomic unsigned maximum on byte in memory, without return, atomically loads an 8-bit byte from memory, compares it against the value held in a register, and stores the larger value back to memory, treating the values as unsigned numbers.

- STUMAXB does not have release semantics.
  - STUMAXB stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.
- For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDUMAXB, LDUMAXB, LDUMAXB, LDUMAXB](#). This means:

- The encodings in this description are named to match the encodings of [LDUMAXB, LDUMAXB, LDUMAXB, LDUMAXB](#).
- The description of [LDUMAXB, LDUMAXB, LDUMAXB, LDUMAXB](#) gives the operational pseudocode for this instruction.

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	0	R	1	Rs				0	1	1	0	0	0	Rn				1	1	1	1	1		
size					A					opc										Rt											

### No memory ordering (R == 0)

STUMAXB <Ws>, [[<Xn|SP>](#)]

is equivalent to

[LDUMAXB](#) <Ws>, WZR, [[<Xn|SP>](#)]

and is always the preferred disassembly.

### Release (R == 1)

STUMAXB <Ws>, [[<Xn|SP>](#)]

is equivalent to

[LDUMAXB](#) <Ws>, WZR, [[<Xn|SP>](#)]

and is always the preferred disassembly.

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDUMAXB, LDUMAXB, LDUMAXB, LDUMAXB](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

# STUMAXH, STUMAXLH

Atomic unsigned maximum on halfword in memory, without return, atomically loads a 16-bit halfword from memory, compares it against the value held in a register, and stores the larger value back to memory, treating the values as unsigned numbers.

- STUMAXH does not have release semantics.
- STUMAXLH stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDUMAXH](#), [LDUMAXAH](#), [LDUMAXALH](#), [LDUMAXLH](#). This means:

- The encodings in this description are named to match the encodings of [LDUMAXH](#), [LDUMAXAH](#), [LDUMAXALH](#), [LDUMAXLH](#).
- The description of [LDUMAXH](#), [LDUMAXAH](#), [LDUMAXALH](#), [LDUMAXLH](#) gives the operational pseudocode for this instruction.

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	0	R	1	Rs					0	1	1	0	0	0	Rn					1	1	1	1	1
size					A					opc												Rt									

### No memory ordering (R == 0)

STUMAXH <Ws>, [<Xn|SP>]

is equivalent to

[LDUMAXH](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### Release (R == 1)

STUMAXLH <Ws>, [<Xn|SP>]

is equivalent to

[LDUMAXLH](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDUMAXH](#), [LDUMAXAH](#), [LDUMAXALH](#), [LDUMAXLH](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# STUMIN, STUMINL

Atomic unsigned minimum on word or doubleword in memory, without return, atomically loads a 32-bit word or 64-bit doubleword from memory, compares it against the value held in a register, and stores the smaller value back to memory, treating the values as unsigned numbers.

- STUMIN does not have release semantics.
- STUMINL stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDUMIN, LDUMINA, LDUMINAL, LDUMINL](#). This means:

- The encodings in this description are named to match the encodings of [LDUMIN, LDUMINA, LDUMINAL, LDUMINL](#).
- The description of [LDUMIN, LDUMINA, LDUMINAL, LDUMINL](#) gives the operational pseudocode for this instruction.

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	0	0	R	1	Rs				0	1	1	1	0	0	Rn				1	1	1	1	1		
size				A								opc								Rt											

### 32-bit LDUMIN alias (size == 10 && R == 0)

STUMIN <Ws>, [<Xn|SP>]

is equivalent to

[LDUMIN](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### 32-bit LDUMINL alias (size == 10 && R == 1)

STUMINL <Ws>, [<Xn|SP>]

is equivalent to

[LDUMINL](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### 64-bit LDUMIN alias (size == 11 && R == 0)

STUMIN <Xs>, [<Xn|SP>]

is equivalent to

[LDUMIN](#) <Xs>, XZR, [<Xn|SP>]

and is always the preferred disassembly.

### 64-bit LDUMINL alias (size == 11 && R == 1)

STUMINL <Xs>, [<Xn|SP>]

is equivalent to

[LDUMINL](#) <Xs>, XZR, [<Xn|SP>]

and is always the preferred disassembly.



## Assembler Symbols

<Ws>	Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xs>	Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDUMIN](#), [LDUMINA](#), [LDUMINAL](#), [LDUMINL](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# STUMINB, STUMINLB

Atomic unsigned minimum on byte in memory, without return, atomically loads an 8-bit byte from memory, compares it against the value held in a register, and stores the smaller value back to memory, treating the values as unsigned numbers.

- STUMINB does not have release semantics.
- STUMINLB stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDUMINB, LDUMINAB, LDUMINALB, LDUMINLB](#). This means:

- The encodings in this description are named to match the encodings of [LDUMINB, LDUMINAB, LDUMINALB, LDUMINLB](#).
- The description of [LDUMINB, LDUMINAB, LDUMINALB, LDUMINLB](#) gives the operational pseudocode for this instruction.

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	0	R	1	Rs					0	1	1	1	0	0	Rn					1	1	1	1	1
size					A					opc															Rt						

### No memory ordering (R == 0)

STUMINB <Ws>, [<Xn|SP>]

is equivalent to

[LDUMINB](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### Release (R == 1)

STUMINLB <Ws>, [<Xn|SP>]

is equivalent to

[LDUMINLB](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDUMINB, LDUMINAB, LDUMINALB, LDUMINLB](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

# STUMINH, STUMINLH

Atomic unsigned minimum on halfword in memory, without return, atomically loads a 16-bit halfword from memory, compares it against the value held in a register, and stores the smaller value back to memory, treating the values as unsigned numbers.

- STUMINH does not have release semantics.
- STUMINLH stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDUMINH, LDUMINAH, LDUMINALH, LDUMINLH](#). This means:

- The encodings in this description are named to match the encodings of [LDUMINH, LDUMINAH, LDUMINALH, LDUMINLH](#).
- The description of [LDUMINH, LDUMINAH, LDUMINALH, LDUMINLH](#) gives the operational pseudocode for this instruction.

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	0	R	1	Rs					0	1	1	1	0	0	Rn					1	1	1	1	1
size					A					opc										Rt											

### No memory ordering (R == 0)

STUMINH <Ws>, [<Xn|SP>]

is equivalent to

[LDUMINH](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### Release (R == 1)

STUMINLH <Ws>, [<Xn|SP>]

is equivalent to

[LDUMINLH](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

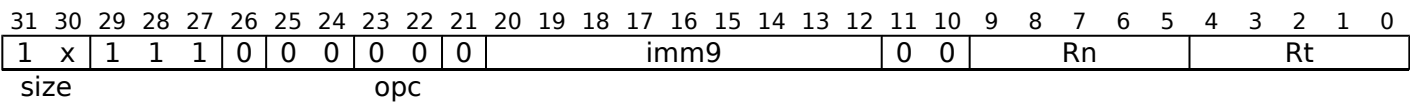
The description of [LDUMINH, LDUMINAH, LDUMINALH, LDUMINLH](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

# STUR

Store Register (unscaled) calculates an address from a base register value and an immediate offset, and stores a 32-bit word or a 64-bit doubleword to the calculated address, from a register. For information about memory accesses, see [Load/Store addressing modes](#).



## 32-bit (size == 10)

```
STUR <Wt>, [<Xn|SP>{, #<sim>}]
```

## 64-bit (size == 11)

```
STUR <Xt>, [<Xn|SP>{, #<sim>}]
```

```
integer scale = UInt(size);
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

integer datasize = 8 << scale;
boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(datasize) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = X[t];
Mem[address, datasize DIV 8, AccType_NORMAL] = data;
```

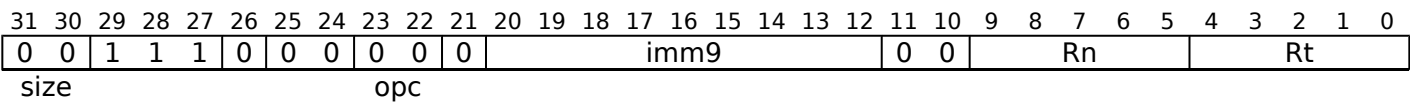
## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.



# STURB

Store Register Byte (unscaled) calculates an address from a base register value and an immediate offset, and stores a byte to the calculated address, from a 32-bit register. For information about memory accesses, see [Load/Store addressing modes](#).



STURB <Wt>, [<Xn|SP>{, #<simm>}]

```
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <simm> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(8) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = X[t];
Mem[address, 1, AccType_NORMAL] = data;
```

## Operational information

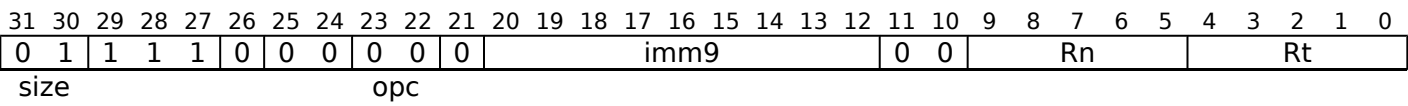
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# STURH

Store Register Halfword (unscaled) calculates an address from a base register value and an immediate offset, and stores a halfword to the calculated address, from a 32-bit register. For information about memory accesses, see [Load/Store addressing modes](#).



STURH <Wt>, [<Xn|SP>{, #<simm>}]

```
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <simm> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(16) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = X[t];
Mem[address, 2, AccType_NORMAL] = data;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## STXP

Store Exclusive Pair of registers stores two 32-bit words or two 64-bit doublewords from two registers to a memory location if the PE has exclusive access to the memory address, and returns a status value of 0 if the store was successful, or of 1 if no store was performed. See [Synchronization and semaphores](#). For information on single-copy atomicity and alignment requirements, see [Requirements for single-copy atomicity](#) and [Alignment of data accesses](#). If a 64-bit pair Store-Exclusive succeeds, it causes a single-copy atomic update of the 128-bit memory location being updated. For information about memory accesses, see [Load/Store addressing modes](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	sz	0	0	1	0	0	0	0	0	1	Rs				0	Rt2				Rn				Rt							
L										o0																					

### 32-bit (sz == 0)

STXP <Ws>, <Wt1>, <Wt2>, [<Xn|SP>{, #0}]

### 64-bit (sz == 1)

STXP <Ws>, <Xt1>, <Xt2>, [<Xn|SP>{, #0}]

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer t2 = UInt(Rt2);    // ignored by load/store single register
integer s = UInt(Rs);      // ignored by all loads and store-release

integer elsize = 32 << UInt(sz);
integer datasize = elsize * 2;
boolean tag_checked = n != 31;

boolean rt_unknown = FALSE;
boolean rn_unknown = FALSE;
if s == t || (s == t2) then
    Constraint c = ConstrainUnpredictable(Unpredictable_DATAOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rt_unknown = TRUE;    // store UNKNOWN value
        when Constraint_NONE     rt_unknown = FALSE;   // store original value
        when Constraint_UNDEF     UNDEFINED;
        when Constraint_NOP       EndOfInstruction();
if s == n && n != 31 then
    Constraint c = ConstrainUnpredictable(Unpredictable_BASEOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rn_unknown = TRUE;    // address is UNKNOWN
        when Constraint_NONE     rn_unknown = FALSE;   // address is original base
        when Constraint_UNDEF     UNDEFINED;
        when Constraint_NOP       EndOfInstruction();
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [STXP](#).

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register into which the status result of the store exclusive is written, encoded in the "Rs" field. The value returned is:
- 0 If the operation updates memory.
  - 1 If the operation fails to update memory.
- <Xt1> Is the 64-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.



- <Xt2> Is the 64-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
- <Wt1> Is the 32-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
- <Wt2> Is the 32-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

#### Aborts and alignment

If a synchronous Data Abort exception is generated by the execution of this instruction:

- Memory is not updated.
- <Ws> is not updated.

Accessing an address that is not aligned to the size of the data being accessed causes an Alignment fault Data Abort exception to be generated, subject to the following rules:

- If AArch64.ExclusiveMonitorsPass() returns TRUE, the exception is generated.
- Otherwise, it is IMPLEMENTATION DEFINED whether the exception is generated.

If AArch64.ExclusiveMonitorsPass() returns FALSE and the memory address, if accessed, would generate a synchronous Data Abort exception, it is IMPLEMENTATION DEFINED whether the exception is generated.

## Operation

```
bits(64) address;
bits(datasize) data;
constant integer dbytes = datasize DIV 8;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
elseif rn_unknown then
    address = bits(64) UNKNOWN;
else
    address = X[n];

if rt_unknown then
    data = bits(datasize) UNKNOWN;
else
    bits(datasize DIV 2) el1 = X[t];
    bits(datasize DIV 2) el2 = X[t2];
    data = if BigEndian(AccType_ATOMIC) then el1:el2 else el2:el1;
bit status = '1';
// Check whether the Exclusives monitors are set to include the
// physical memory locations corresponding to virtual address
// range [address, address+dbytes-1].
if AArch64.ExclusiveMonitorsPass(address, dbytes) then
    // This atomic write will be rejected if it does not refer
    // to the same physical locations after address translation.
    Mem[address, dbytes, AccType_ATOMIC] = data;
    status = ExclusiveMonitorsStatus();
X[s] = ZeroExtend(status, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## STXR

Store Exclusive Register stores a 32-bit word or a 64-bit doubleword from a register to memory if the PE has exclusive access to the memory address, and returns a status value of 0 if the store was successful, or of 1 if no store was performed. See [Synchronization and semaphores](#). For information about memory accesses see [Load/Store addressing modes](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	0	0	1	0	0	0	0	0	0					Rs	0	(1)	(1)	(1)	(1)	(1)										
size								L				o0				Rt2						Rn						Rt			

### 32-bit (size == 10)

STXR <Ws>, <Wt>, [<Xn|SP>{, #0}]

### 64-bit (size == 11)

STXR <Ws>, <Xt>, [<Xn|SP>{, #0}]

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer s = UInt(Rs);    // ignored by all loads and store-release

integer elsize = 8 << UInt(size);
boolean tag_checked = n != 31;

boolean rt_unknown = FALSE;
boolean rn_unknown = FALSE;
if s == t then
    Constraint c = ConstrainUnpredictable(Unpredictable_DATAOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rt_unknown = TRUE;    // store UNKNOWN value
        when Constraint_NONE     rt_unknown = FALSE;   // store original value
        when Constraint_UNDEF     UNDEFINED;
        when Constraint_NOP       EndOfInstruction();
if s == n && n != 31 then
    Constraint c = ConstrainUnpredictable(Unpredictable_BASEOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rn_unknown = TRUE;    // address is UNKNOWN
        when Constraint_NONE     rn_unknown = FALSE;   // address is original base
        when Constraint_UNDEF     UNDEFINED;
        when Constraint_NOP       EndOfInstruction();
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [STXR](#).

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register into which the status result of the store exclusive is written, encoded in the "Rs" field. The value returned is:
- 0 If the operation updates memory.
  - 1 If the operation fails to update memory.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- Aborts and alignment

If a synchronous Data Abort exception is generated by the execution of this instruction:

- Memory is not updated.
- <Ws> is not updated.

Accessing an address that is not aligned to the size of the data being accessed causes an Alignment fault Data Abort exception to be generated, subject to the following rules:

- If AArch64.ExclusiveMonitorsPass() returns TRUE, the exception is generated.
- Otherwise, it is IMPLEMENTATION DEFINED whether the exception is generated.

If AArch64.ExclusiveMonitorsPass() returns FALSE and the memory address, if accessed, would generate a synchronous Data Abort exception, it is IMPLEMENTATION DEFINED whether the exception is generated.

## Operation

```
bits(64) address;
bits(elsize) data;
constant integer dbytes = elsize DIV 8;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
elseif rn_unknown then
    address = bits(64) UNKNOWN;
else
    address = X[n];

if rt_unknown then
    data = bits(elsize) UNKNOWN;
else
    data = X[t];

bit status = '1';
// Check whether the Exclusives monitors are set to include the
// physical memory locations corresponding to virtual address
// range [address, address+dbytes-1].
if AArch64.ExclusiveMonitorsPass(address, dbytes) then
    // This atomic write will be rejected if it does not refer
    // to the same physical locations after address translation.
    Mem[address, dbytes, AccType_ATOMIC] = data;
    status = ExclusiveMonitorsStatus();
X[s] = ZeroExtend(status, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## STXRB

Store Exclusive Register Byte stores a byte from a register to memory if the PE has exclusive access to the memory address, and returns a status value of 0 if the store was successful, or of 1 if no store was performed. See [Synchronization and semaphores](#). The memory access is atomic.

For information about memory accesses see [Load/Store addressing modes](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	1	0	0	0	0	0	0	Rs				0	(1)	(1)	(1)	(1)	(1)	Rn				Rt						
size								L				o0				Rt2															

**STXRB** <Ws>, <Wt>, [<Xn|SP>{, #0}]

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer s = UInt(Rs);    // ignored by all loads and store-release

boolean tag_checked = n != 31;

boolean rt_unknown = FALSE;
boolean rn_unknown = FALSE;
if s == t then
    Constraint c = ConstrainUnpredictable(Unpredictable_DATAOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rt_unknown = TRUE;    // store UNKNOWN value
        when Constraint_NONE    rt_unknown = FALSE;   // store original value
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();
if s == n && n != 31 then
    Constraint c = ConstrainUnpredictable(Unpredictable_BASEOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rn_unknown = TRUE;    // address is UNKNOWN
        when Constraint_NONE    rn_unknown = FALSE;   // address is original base
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [STXRB](#).

## Assembler Symbols

<Ws> Is the 32-bit name of the general-purpose register into which the status result of the store exclusive is written, encoded in the "Rs" field. The value returned is:

**0**

If the operation updates memory.

**1**

If the operation fails to update memory.

<Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.

<Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

### Aborts

If a synchronous Data Abort exception is generated by the execution of this instruction:

- Memory is not updated.
- <Ws> is not updated.

If AArch64.ExclusiveMonitorsPass() returns FALSE and the memory address, if accessed, would generate a synchronous Data Abort exception, it is IMPLEMENTATION DEFINED whether the exception is generated.

## Operation

```
bits(64) address;
bits(8) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
elsif rn_unknown then
    address = bits(64) UNKNOWN;
else
    address = X[n];

if rt_unknown then
    data = bits(8) UNKNOWN;
else
    data = X[t];

bit status = '1';
// Check whether the Exclusives monitors are set to include the
// physical memory locations corresponding to virtual address
// range [address, address+dbytes-1].
if AAarch64.ExclusiveMonitorsPass(address, 1) then
    // This atomic write will be rejected if it does not refer
    // to the same physical locations after address translation.
    Mem[address, 1, AccType_ATOMIC] = data;
    status = ExclusiveMonitorsStatus();
X[s] = ZeroExtend(status, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## STXRH

Store Exclusive Register Halfword stores a halfword from a register to memory if the PE has exclusive access to the memory address, and returns a status value of 0 if the store was successful, or of 1 if no store was performed. See [Synchronization and semaphores](#). The memory access is atomic.

For information about memory accesses see [Load/Store addressing modes](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	1	0	0	0	0	0	0	Rs				0	(1)	(1)	(1)	(1)	(1)	Rn				Rt						
size		L								o0		Rt2																			

**STXRH** <Ws>, <Wt>, [<Xn|SP>{, #0}]

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer s = UInt(Rs);    // ignored by all loads and store-release

boolean tag_checked = n != 31;

boolean rt_unknown = FALSE;
boolean rn_unknown = FALSE;
if s == t then
    Constraint c = ConstrainUnpredictable(Unpredictable_DATAOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rt_unknown = TRUE;    // store UNKNOWN value
        when Constraint_NONE     rt_unknown = FALSE;   // store original value
        when Constraint_UNDEF     UNDEFINED;
        when Constraint_NOP       EndOfInstruction();
if s == n && n != 31 then
    Constraint c = ConstrainUnpredictable(Unpredictable_BASEOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rn_unknown = TRUE;    // address is UNKNOWN
        when Constraint_NONE     rn_unknown = FALSE;   // address is original base
        when Constraint_UNDEF     UNDEFINED;
        when Constraint_NOP       EndOfInstruction();
```

## Assembler Symbols

<Ws> Is the 32-bit name of the general-purpose register into which the status result of the store exclusive is written, encoded in the "Rs" field. The value returned is:

**0**

If the operation updates memory.

**1**

If the operation fails to update memory.

<Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.

<Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Aborts and alignment

If a synchronous Data Abort exception is generated by the execution of this instruction:

- Memory is not updated.
- <Ws> is not updated.

A non halfword-aligned memory address causes an Alignment fault Data Abort exception to be generated, subject to the following rules:

- If AArch64.ExclusiveMonitorsPass() returns TRUE, the exception is generated.
- Otherwise, it is IMPLEMENTATION DEFINED whether the exception is generated.

If AArch64.ExclusiveMonitorsPass() returns FALSE and the memory address, if accessed, would generate a synchronous Data Abort exception, it is IMPLEMENTATION DEFINED whether the exception is generated.

## Operation

```
bits(64) address;
bits(16) data;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
elsif rn_unknown then
    address = bits(64) UNKNOWN;
else
    address = X[n];

if rt_unknown then
    data = bits(16) UNKNOWN;
else
    data = X[t];

bit status = '1';
// Check whether the Exclusives monitors are set to include the
// physical memory locations corresponding to virtual address
// range [address, address+dbytes-1].
if AAarch64.ExclusiveMonitorsPass(address, 2) then
    // This atomic write will be rejected if it does not refer
    // to the same physical locations after address translation.
    Mem[address, 2, AccType_ATOMIC] = data;
    status = ExclusiveMonitorsStatus();
X[s] = ZeroExtend(status, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## STZ2G

Store Allocation Tags, Zeroing stores an Allocation Tag to two Tag granules of memory, zeroing the associated data locations. The address used for the store is calculated from the base register and an immediate signed offset scaled by the Tag granule. The Allocation Tag is calculated from the Logical Address Tag in the source register.

This instruction generates an Unchecked access.

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Signed offset](#)

### Post-index (FEAT\_MTE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	1	1	1	imm9									0	1	Xn				Xt					

STZ2G <Xt|SP>, [<Xn|SP>], #<sim>

```
if !HaveMTEExt() then UNDEFINED;
integer n = UInt(Xn);
integer t = UInt(Xt);
bits(64) offset = LSL(SignExtend(imm9, 64), LOG2_TAG_GRANULE);
boolean writeback = TRUE;
boolean postindex = TRUE;
```

### Pre-index (FEAT\_MTE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	1	1	1	imm9									1	1	Xn				Xt					

STZ2G <Xt|SP>, [<Xn|SP>, #<sim>]!

```
if !HaveMTEExt() then UNDEFINED;
integer n = UInt(Xn);
integer t = UInt(Xt);
bits(64) offset = LSL(SignExtend(imm9, 64), LOG2_TAG_GRANULE);
boolean writeback = TRUE;
boolean postindex = FALSE;
```

### Signed offset (FEAT\_MTE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	1	1	1	imm9									1	0	Xn				Xt					

STZ2G <Xt|SP>, [<Xn|SP>{, #<sim>}]

```
if !HaveMTEExt() then UNDEFINED;
integer n = UInt(Xn);
integer t = UInt(Xt);
bits(64) offset = LSL(SignExtend(imm9, 64), LOG2_TAG_GRANULE);
boolean writeback = FALSE;
boolean postindex = FALSE;
```

## Assembler Symbols

- <Xt|SP> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Xt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Xn" field.



<sim> Is the optional signed immediate offset, a multiple of 16 in the range -4096 to 4080, defaulting to 0 and encoded in the "imm9" field.

## Operation

```
bits(64) address;
bits(64) data = if t == 31 then SP[] else X[t];
bits(4) tag = AArch64.AllocationTagFromAddress(data);

SetTagCheckedInstruction(FALSE);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

if address != Align(address, TAG_GRANULE) then
    AArch64.Abort(address, AlignmentFault(AccType_NORMAL, TRUE, FALSE));

Mem[address, TAG_GRANULE, AccType_NORMAL] = Zeros(TAG_GRANULE * 8);
Mem[address+TAG_GRANULE, TAG_GRANULE, AccType_NORMAL] = Zeros(TAG_GRANULE * 8);

AArch64.MemTag[address, AccType_NORMAL] = tag;
AArch64.MemTag[address+TAG_GRANULE, AccType_NORMAL] = tag;

if writeback then
    if postindex then
        address = address + offset;

    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## STZG

Store Allocation Tag, Zeroing stores an Allocation Tag to memory, zeroing the associated data location. The address used for the store is calculated from the base register and an immediate signed offset scaled by the Tag granule. The Allocation Tag is calculated from the Logical Address Tag in the source register.

This instruction generates an Unchecked access.

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Signed offset](#)

### Post-index (FEAT\_MTE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	0	1	1	imm9									0	1	Xn				Xt					

STZG <Xt|SP>, [<Xn|SP>], #<simm>

```
if !HaveMTEExt() then UNDEFINED;
integer n = UInt(Xn);
integer t = UInt(Xt);
bits(64) offset = LSL(SignExtend(imm9, 64), LOG2_TAG_GRANULE);
boolean writeback = TRUE;
boolean postindex = TRUE;
```

### Pre-index (FEAT\_MTE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	0	1	1	imm9									1	1	Xn				Xt					

STZG <Xt|SP>, [<Xn|SP>, #<simm>]!

```
if !HaveMTEExt() then UNDEFINED;
integer n = UInt(Xn);
integer t = UInt(Xt);
bits(64) offset = LSL(SignExtend(imm9, 64), LOG2_TAG_GRANULE);
boolean writeback = TRUE;
boolean postindex = FALSE;
```

### Signed offset (FEAT\_MTE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	0	1	1	imm9									1	0	Xn				Xt					

STZG <Xt|SP>, [<Xn|SP>{, #<simm>}]

```
if !HaveMTEExt() then UNDEFINED;
integer n = UInt(Xn);
integer t = UInt(Xt);
bits(64) offset = LSL(SignExtend(imm9, 64), LOG2_TAG_GRANULE);
boolean writeback = FALSE;
boolean postindex = FALSE;
```

## Assembler Symbols

- <Xt|SP>      Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Xt" field.
- <Xn|SP>      Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Xn" field.

<sim> Is the optional signed immediate offset, a multiple of 16 in the range -4096 to 4080, defaulting to 0 and encoded in the "imm9" field.

## Operation

```
bits(64) address;

SetTagCheckedInstruction(FALSE);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

if address != Align(address, TAG_GRANULE) then
    AArch64.Abort(address, AlignmentFault(AccType_NORMAL, TRUE, FALSE));

Mem[address, TAG_GRANULE, AccType_NORMAL] = Zeros(TAG_GRANULE * 8);

bits(64) data = if t == 31 then SP[] else X[t];
bits(4) tag = AArch64.AllocationTagFromAddress(data);
AArch64.MemTag[address, AccType_NORMAL] = tag;

if writeback then
    if postindex then
        address = address + offset;

    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# STZGM

Store Tag and Zero Multiple writes a naturally aligned block of N Allocation Tags and stores zero to the associated data locations, where the size of N is identified in DCZID\_EL0.BS, and the Allocation Tag written to address A is taken from the source register bits<3:0>.

This instruction is UNDEFINED at EL0.

This instruction generates an Unchecked access.

If *ID\_AA64PFR1\_EL1.MTE* != 0b0010, this instruction is UNDEFINED.

## Integer (FEAT\_MTE2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	Xn					Xt				

STZGM <Xt>, [<Xn|SP>]

```
if !HaveMTE2Ext() then UNDEFINED;
integer t = UInt(Xt);
integer n = UInt(Xn);
```

## Assembler Symbols

- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Xt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Xn" field.

## Operation

```
if PSTATE.EL == EL0 then
    UNDEFINED;

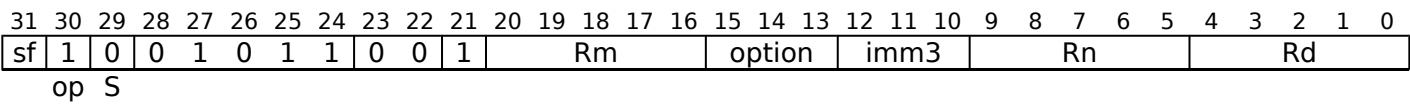
bits(64) data = X[t];
bits(4) tag = data<3:0>;
bits(64) address;
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

integer size = 4 * (2 ^ (UInt(DCZID_EL0.BS)));
address = Align(address, size);
integer count = size >> LOG2_TAG_GRANULE;

for i = 0 to count-1
    AArch64.MemTag[address, AccType_NORMAL] = tag;
    Mem[address, TAG_GRANULE, AccType_NORMAL] = Zeros(8 * TAG_GRANULE);
    address = address + TAG_GRANULE;
```

## SUB (extended register)

Subtract (extended register) subtracts a sign or zero-extended register value, followed by an optional left shift amount, from a register value, and writes the result to the destination register. The argument that is extended from the <Rm> register can be a byte, halfword, word, or doubleword.



### 32-bit (sf == 0)

SUB <Wd|WSP>, <Wn|WSP>, <Wm>{, <extend> {#<amount>}}

### 64-bit (sf == 1)

SUB <Xd|SP>, <Xn|SP>, <R><m>{, <extend> {#<amount>}}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
ExtendType extend_type = DecodeRegExtend(option);
integer shift = UInt(imm3);
if shift > 4 then UNDEFINED;
```

## Assembler Symbols

- <Wd|WSP> Is the 32-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Wn|WSP> Is the 32-bit name of the first source general-purpose register or stack pointer, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd|SP> Is the 64-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Xn|SP> Is the 64-bit name of the first source general-purpose register or stack pointer, encoded in the "Rn" field.
- <R> Is a width specifier, encoded in "option":

option	<R>
00x	W
010	W
x11	X
10x	W
110	W
- <m> Is the number [0-30] of the second general-purpose source register or the name ZR (31), encoded in the "Rm" field.
- <extend> For the 32-bit variant: is the extension to be applied to the second source operand, encoded in "option":

option	<extend>
000	UXTB
001	UXTH
010	LSL UXTW
011	UXTX
100	SXTB
101	SXTH
110	SXTW
111	SXTX

If "Rd" or "Rn" is '11111' (WSP) and "option" is '010' then LSL is preferred, but may be omitted when "imm3" is '000'. In all other cases <extend> is required and must be UXTW when "option" is '010'.

For the 64-bit variant: is the extension to be applied to the second source operand, encoded in "option":

option	<extend>
000	UXTB
001	UXTH
010	UXTW
011	LSL UXTX
100	SXTB
101	SXTH
110	SXTW
111	SXTX

If "Rd" or "Rn" is '11111' (SP) and "option" is '011' then LSL is preferred, but may be omitted when "imm3" is '000'. In all other cases <extend> is required and must be UXTX when "option" is '011'.

<amount> Is the left shift amount to be applied after extension in the range 0 to 4, defaulting to 0, encoded in the "imm3" field. It must be absent when <extend> is absent, is required when <extend> is LSL, and is optional when <extend> is present but not LSL.

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = if n == 31 then SP[] else X[n];
bits(datasize) operand2 = ExtendReg(m, extend_type, shift);

operand2 = NOT(operand2);
(result, -) = AddWithCarry(operand1, operand2, '1');

if d == 31 then
    SP[] = result;
else
    X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

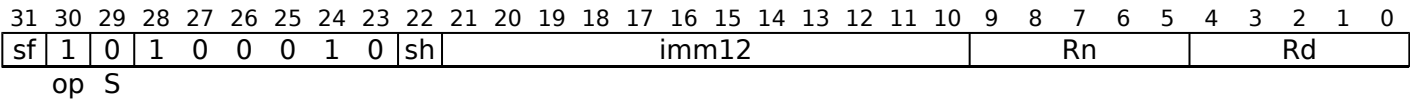
- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SUB (immediate)

Subtract (immediate) subtracts an optionally-shifted immediate value from a register value, and writes the result to the destination register.



## 32-bit (sf == 0)

SUB <Wd|WSP>, <Wn|WSP>, #<imm>{, <shift>}

## 64-bit (sf == 1)

SUB <Xd|SP>, <Xn|SP>, #<imm>{, <shift>}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer datasize = if sf == '1' then 64 else 32;
bits(datasize) imm;

case sh of
    when '0' imm = ZeroExtend(imm12, datasize);
    when '1' imm = ZeroExtend(imm12:Zeros(12), datasize);
```

## Assembler Symbols

- <Wd|WSP> Is the 32-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Wn|WSP> Is the 32-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.
- <Xd|SP> Is the 64-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Xn|SP> Is the 64-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.
- <imm> Is an unsigned immediate, in the range 0 to 4095, encoded in the "imm12" field.
- <shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #12

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = if n == 31 then SP[] else X[n];
bits(datasize) operand2;

operand2 = NOT(imm);
(result, -) = AddWithCarry(operand1, operand2, '1');

if d == 31 then
    SP[] = result;
else
    X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

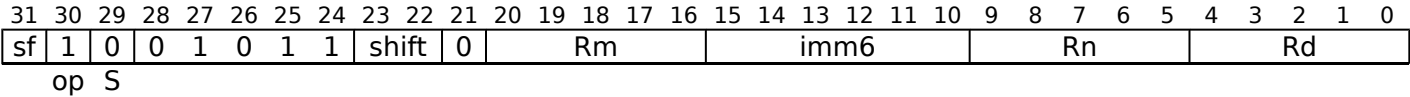
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



## SUB (shifted register)

Subtract (shifted register) subtracts an optionally-shifted register value from a register value, and writes the result to the destination register.

This instruction is used by the alias [NEG \(shifted register\)](#).



### 32-bit (sf == 0)

SUB <Wd>, <Wn>, <Wm>{, <shift> #<amount>}

### 64-bit (sf == 1)

SUB <Xd>, <Xn>, <Xm>{, <shift> #<amount>}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;

if shift == '11' then UNDEFINED;
if sf == '0' && imm6<5> == '1' then UNDEFINED;

ShiftType shift_type = DecodeShift(shift);
integer shift_amount = UInt(imm6);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <shift> Is the optional shift type to be applied to the second source operand, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	RESERVED

- <amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.  
For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">NEG (shifted register)</a>	Rn == '11111'

## Operation

```
bits(datasize) result;  
bits(datasize) operand1 = X[n];  
bits(datasize) operand2 = ShiftReg(m, shift_type, shift_amount);  
  
operand2 = NOT(operand2);  
(result, -) = AddWithCarry(operand1, operand2, '1');  
  
X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

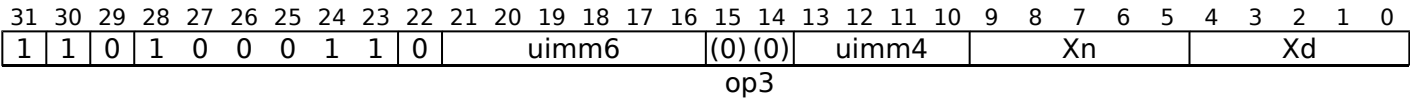
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SUBG

Subtract with Tag subtracts an immediate value scaled by the Tag granule from the address in the source register, modifies the Logical Address Tag of the address using an immediate value, and writes the result to the destination register. Tags specified in GCR\_EL1.Exclude are excluded from the possible outputs when modifying the Logical Address Tag.

## Integer (FEAT\_MTE)



SUBG <Xd|SP>, <Xn|SP>, #<uimm6>, #<uimm4>

```
if !HaveMTEExt() then UNDEFINED;
integer d = UInt(Xd);
integer n = UInt(Xn);
bits(64) offset = LSL(ZeroExtend(uimm6, 64), LOG2_TAG_GRANULE);
```

## Assembler Symbols

- <Xd|SP> Is the 64-bit name of the destination general-purpose register or stack pointer, encoded in the "Xd" field.
- <Xn|SP> Is the 64-bit name of the source general-purpose register or stack pointer, encoded in the "Xn" field.
- <uimm6> Is an unsigned immediate, a multiple of 16 in the range 0 to 1008, encoded in the "uimm6" field.
- <uimm4> Is an unsigned immediate, in the range 0 to 15, encoded in the "uimm4" field.

## Operation

```
bits(64) operand1 = if n == 31 then SP[] else X[n];
bits(4) start_tag = AArch64.AllocationTagFromAddress(operand1);
bits(16) exclude = GCR_EL1.Exclude;
bits(64) result;
bits(4) rtag;

if AArch64.AllocationTagAccessIsEnabled(AccType_NORMAL) then
    rtag = AArch64.ChooseNonExcludedTag(start_tag, uimm4, exclude);
else
    rtag = '0000';

(result, -) = AddWithCarry(operand1, NOT(offset), '1');

result = AArch64.AddressWithAllocationTag(result, AccType_NORMAL, rtag);

if d == 31 then
    SP[] = result;
else
    X[d] = result;
```

SUBP

Subtract Pointer subtracts the 56-bit address held in the second source register from the 56-bit address held in the first source register, sign-extends the result to 64-bits, and writes the result to the destination register.

Integer  
(FEAT\_MTE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	1	0	1	0	1	1	0	Xm					0	0	0	0	0	0	Xn					Xd				

SUBP <Xd>, <Xn|SP>, <Xm|SP>

```
if !HaveMTEExt() then UNDEFINED;
integer d = UInt(Xd);
integer n = UInt(Xn);
integer m = UInt(Xm);
```

Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Xd" field.
- <Xn|SP> Is the 64-bit name of the first source general-purpose register or stack pointer, encoded in the "Xn" field.
- <Xm|SP> Is the 64-bit name of the second general-purpose source register or stack pointer, encoded in the "Xm" field.

Operation

```
bits(64) operand1 = if n == 31 then SP[] else X[n];
bits(64) operand2 = if m == 31 then SP[] else X[m];
operand1 = SignExtend(operand1<55:0>, 64);
operand2 = SignExtend(operand2<55:0>, 64);

bits(64) result;

operand2 = NOT(operand2);
(result, -) = AddWithCarry(operand1, operand2, '1');

X[d] = result;
```

# SUBPS

Subtract Pointer, setting Flags subtracts the 56-bit address held in the second source register from the 56-bit address held in the first source register, sign-extends the result to 64-bits, and writes the result to the destination register. It updates the condition flags based on the result of the subtraction.

This instruction is used by the alias [CMPP](#).

## Integer (FEAT\_MTE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	1	1	0	1	0	1	1	0	Xm				0	0	0	0	0	0	Xn				Xd						

SUBPS <Xd>, <Xn|SP>, <Xm|SP>

```
if !HaveMTEExt() then UNDEFINED;
integer d = UInt(Xd);
integer n = UInt(Xn);
integer m = UInt(Xm);
```

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Xd" field.
- <Xn|SP> Is the 64-bit name of the first source general-purpose register or stack pointer, encoded in the "Xn" field.
- <Xm|SP> Is the 64-bit name of the second general-purpose source register or stack pointer, encoded in the "Xm" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">CMPP</a>	S == '1' && Xd == '11111'

## Operation

```
bits(64) operand1 = if n == 31 then SP[] else X[n];
bits(64) operand2 = if m == 31 then SP[] else X[m];
operand1 = SignExtend(operand1<55:0>, 64);
operand2 = SignExtend(operand2<55:0>, 64);

bits(64) result;
bits(4) nzcvc;

operand2 = NOT(operand2);
(result, nzcvc) = AddWithCarry(operand1, operand2, '1');

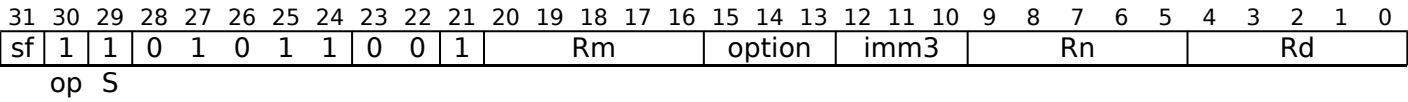
PSTATE.<N,Z,C,V> = nzcvc;
X[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41  
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## SUBS (extended register)

Subtract (extended register), setting flags, subtracts a sign or zero-extended register value, followed by an optional left shift amount, from a register value, and writes the result to the destination register. The argument that is extended from the <Rm> register can be a byte, halfword, word, or doubleword. It updates the condition flags based on the result.

This instruction is used by the alias [CMP \(extended register\)](#).



### 32-bit (sf == 0)

SUBS <Wd>, <Wn|WSP>, <Wm>{, <extend> {#<amount>}}

### 64-bit (sf == 1)

SUBS <Xd>, <Xn|SP>, <R><m>{, <extend> {#<amount>}}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
ExtendType extend_type = DecodeRegExtend(option);
integer shift = UInt(imm3);
if shift > 4 then UNDEFINED;
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn|WSP> Is the 32-bit name of the first source general-purpose register or stack pointer, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn|SP> Is the 64-bit name of the first source general-purpose register or stack pointer, encoded in the "Rn" field.
- <R> Is a width specifier, encoded in "option":

option	<R>
00x	W
010	W
x11	X
10x	W
110	W
- <m> Is the number [0-30] of the second general-purpose source register or the name ZR (31), encoded in the "Rm" field.
- <extend> For the 32-bit variant: is the extension to be applied to the second source operand, encoded in "option":

option	<extend>
000	UXTB
001	UXTH
010	LSL UXTW
011	UXTX
100	SXTB
101	SXTH
110	SXTW
111	SXTX

If "Rn" is '11111' (WSP) and "option" is '010' then LSL is preferred, but may be omitted when "imm3" is '000'. In all other cases <extend> is required and must be UXTW when "option" is '010'.

For the 64-bit variant: is the extension to be applied to the second source operand, encoded in "option":

option	<extend>
000	UXTB
001	UXTH
010	UXTW
011	LSL UXTX
100	SXTB
101	SXTH
110	SXTW
111	SXTX

If "Rn" is '11111' (SP) and "option" is '011' then LSL is preferred, but may be omitted when "imm3" is '000'. In all other cases <extend> is required and must be UXTX when "option" is '011'.

<amount> Is the left shift amount to be applied after extension in the range 0 to 4, defaulting to 0, encoded in the "imm3" field. It must be absent when <extend> is absent, is required when <extend> is LSL, and is optional when <extend> is present but not LSL.

## Alias Conditions

Alias	Is preferred when
<a href="#">CMP (extended register)</a>	Rd == '11111'

## Operation

```

bits(datasize) result;
bits(datasize) operand1 = if n == 31 then SP[] else X[n];
bits(datasize) operand2 = ExtendReg(m, extend_type, shift);
bits(4) nzcvc;

operand2 = NOT(operand2);
(result, nzcvc) = AddWithCarry(operand1, operand2, '1');

PSTATE.<N,Z,C,V> = nzcvc;

X[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

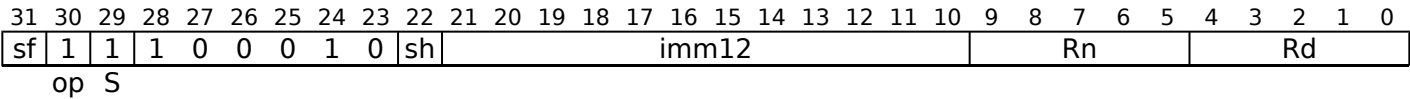
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SUBS (immediate)

Subtract (immediate), setting flags, subtracts an optionally-shifted immediate value from a register value, and writes the result to the destination register. It updates the condition flags based on the result.

This instruction is used by the alias [CMP \(immediate\)](#).



## 32-bit (sf == 0)

SUBS <Wd>, <Wn|WSP>, #<imm>{, <shift>}

## 64-bit (sf == 1)

SUBS <Xd>, <Xn|SP>, #<imm>{, <shift>}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer datasize = if sf == '1' then 64 else 32;
bits(datasize) imm;

case sh of
  when '0' imm = ZeroExtend(imm12, datasize);
  when '1' imm = ZeroExtend(imm12:Zeros(12), datasize);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn|WSP> Is the 32-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn|SP> Is the 64-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.
- <imm> Is an unsigned immediate, in the range 0 to 4095, encoded in the "imm12" field.
- <shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #12

## Alias Conditions

Alias	Is preferred when
<a href="#">CMP (immediate)</a>	Rd == '11111'



## Operation

```
bits(datasize) result;  
bits(datasize) operand1 = if n == 31 then SP[] else X[n];  
bits(datasize) operand2;  
bits(4) nzcvc;  
  
operand2 = NOT(imm);  
(result, nzcvc) = AddWithCarry(operand1, operand2, '1');  
  
PSTATE.<N,Z,C,V> = nzcvc;  
  
X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

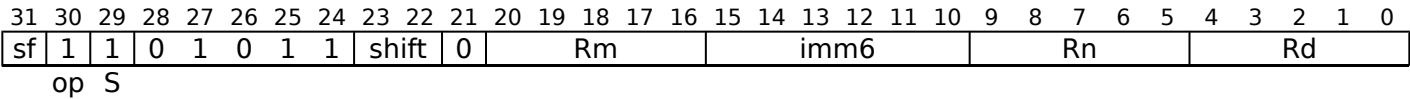
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SUBS (shifted register)

Subtract (shifted register), setting flags, subtracts an optionally-shifted register value from a register value, and writes the result to the destination register. It updates the condition flags based on the result.

This instruction is used by the aliases [CMP \(shifted register\)](#), and [NEGS](#).



## 32-bit (sf == 0)

SUBS <Wd>, <Wn>, <Wm>{, <shift> #<amount>}

## 64-bit (sf == 1)

SUBS <Xd>, <Xn>, <Xm>{, <shift> #<amount>}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;

if shift == '11' then UNDEFINED;
if sf == '0' && imm6<5> == '1' then UNDEFINED;

ShiftType shift_type = DecodeShift(shift);
integer shift_amount = UInt(imm6);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <shift> Is the optional shift type to be applied to the second source operand, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	RESERVED

- <amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.  
For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">CMP (shifted register)</a>	Rd == '11111'
<a href="#">NEGS</a>	Rn == '11111' && Rd != '11111'

## Operation

```
bits(datasize) result;  
bits(datasize) operand1 = X[n];  
bits(datasize) operand2 = ShiftReg(m, shift_type, shift_amount);  
bits(4) nzcvc;  
  
operand2 = NOT(operand2);  
(result, nzcvc) = AddWithCarry(operand1, operand2, '1');  
  
PSTATE.<N,Z,C,V> = nzcvc;  
  
X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SVC

Supervisor Call causes an exception to be taken to EL1.  
On executing an SVC instruction, the PE records the exception as a Supervisor Call exception in *ESR\_ELx*, using the EC value 0x15, and the value of the immediate argument.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	0	0	0	0	imm16																0	0	0	0	1

SVC #<imm>

// Empty.

## Assembler Symbols

<imm> Is a 16-bit unsigned immediate, in the range 0 to 65535, encoded in the "imm16" field.

## Operation

```
AArch64.CheckForSVCTrap(imm16);
AArch64.CallSupervisor(imm16);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41  
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SWP, SWPA, SWPAL, SWPL

Swap word or doubleword in memory atomically loads a 32-bit word or 64-bit doubleword from a memory location, and stores the value held in a register back to the same memory location. The value initially loaded from memory is returned in the destination register.

- If the destination register is not one of WZR or XZR, SWPA and SWPAL load from memory with acquire semantics.
- SWPL and SWPAL store to memory with release semantics.
- SWP has neither acquire nor release semantics.

For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

## Integer

(FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	0	A	R	1	Rs				1	0	0	0	0	0	Rn				Rt						
size																															

### 32-bit SWP (size == 10 && A == 0 && R == 0)

SWP <Ws>, <Wt>, [<Xn|SP>]

### 32-bit SWPA (size == 10 && A == 1 && R == 0)

SWPA <Ws>, <Wt>, [<Xn|SP>]

### 32-bit SWPAL (size == 10 && A == 1 && R == 1)

SWPAL <Ws>, <Wt>, [<Xn|SP>]

### 32-bit SWPL (size == 10 && A == 0 && R == 1)

SWPL <Ws>, <Wt>, [<Xn|SP>]

### 64-bit SWP (size == 11 && A == 0 && R == 0)

SWP <Xs>, <Xt>, [<Xn|SP>]

### 64-bit SWPA (size == 11 && A == 1 && R == 0)

SWPA <Xs>, <Xt>, [<Xn|SP>]

### 64-bit SWPAL (size == 11 && A == 1 && R == 1)

SWPAL <Xs>, <Xt>, [<Xn|SP>]

### 64-bit SWPL (size == 11 && A == 0 && R == 1)

SWPL <Xs>, <Xt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;
```

```
integer t = UInt(Rt);  
integer n = UInt(Rn);  
integer s = UInt(Rs);
```

```
integer datasize = 8 << UInt(size);  
integer regsize = if datasize == 64 then 64 else 32;  
AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;  
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;  
boolean tag_checked = n != 31;
```

## Assembler Symbols

<Ws>	Is the 32-bit name of the general-purpose register to be stored, encoded in the "Rs" field.
<Wt>	Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
<Xs>	Is the 64-bit name of the general-purpose register to be stored, encoded in the "Rs" field.
<Xt>	Is the 64-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(datasize) data;
bits(datasize) store_value;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

store_value = X[s];
data = MemAtomic(address, MemAtomicOp_SWP, store_value, ldacctype, stacctype);
X[t] = ZeroExtend(data, regsize);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SWPB, SWPAB, SWPALB, SWPLB

Swap byte in memory atomically loads an 8-bit byte from a memory location, and stores the value held in a register back to the same memory location. The value initially loaded from memory is returned in the destination register.

- If the destination register is not WZR, SWPAB and SWPALB load from memory with acquire semantics.
- SWPLB and SWPALB store to memory with release semantics.
- SWPB has neither acquire nor release semantics.

For more information about memory ordering semantics see [Load-Acquire, Store-Release](#).

For information about memory accesses see [Load/Store addressing modes](#).

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	A	R	1	Rs				1	0	0	0	0	0	Rn				Rt						
size																															

### SWPAB (A == 1 && R == 0)

SWPAB <Ws>, <Wt>, [<Xn|SP>]

### SWPALB (A == 1 && R == 1)

SWPALB <Ws>, <Wt>, [<Xn|SP>]

### SWPB (A == 0 && R == 0)

SWPB <Ws>, <Wt>, [<Xn|SP>]

### SWPLB (A == 0 && R == 1)

SWPLB <Ws>, <Wt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register to be stored, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.



## Operation

```
bits(64) address;
bits(8) data;
bits(8) store_value;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

store_value = X[s];
data = MemAtomic(address, MemAtomicOp_SWP, store_value, ldacctype, stacctype);
X[t] = ZeroExtend(data, 32);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SWPH, SWPAH, SWPALH, SWPLH

Swap halfword in memory atomically loads a 16-bit halfword from a memory location, and stores the value held in a register back to the same memory location. The value initially loaded from memory is returned in the destination register.

- If the destination register is not WZR, SWPAH and SWPALH load from memory with acquire semantics.
- SWPLH and SWPALH store to memory with release semantics.
- SWPH has neither acquire nor release semantics.

For more information about memory ordering semantics see [Load-Acquire, Store-Release](#).

For information about memory accesses see [Load/Store addressing modes](#).

## Integer (FEAT\_LSE)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	A	R	1	Rs			1	0	0	0	0	0	Rn			Rt								
size																															

### SWPAH (A == 1 && R == 0)

SWPAH <Ws>, <Wt>, [<Xn|SP>]

### SWPALH (A == 1 && R == 1)

SWPALH <Ws>, <Wt>, [<Xn|SP>]

### SWPH (A == 0 && R == 0)

SWPH <Ws>, <Wt>, [<Xn|SP>]

### SWPLH (A == 0 && R == 1)

SWPLH <Ws>, <Wt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register to be stored, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(16) data;
bits(16) store_value;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

store_value = X[s];
data = MemAtomic(address, MemAtomicOp_SWP, store_value, ldacctype, stacctype);
X[t] = ZeroExtend(data, 32);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SXTB

Signed Extend Byte extracts an 8-bit value from a register, sign-extends it to the size of the register, and writes the result to the destination register.

This is an alias of [SBFM](#). This means:

- The encodings in this description are named to match the encodings of [SBFM](#).
- The description of [SBFM](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	0	1	0	0	1	1	0	N	0	0	0	0	0	0	0	0	0	1	1	1	Rn				Rd					
opc									immr							imms															

32-bit (sf == 0 && N == 0)

SXTB <Wd>, <Wn>

is equivalent to

[SBFM](#) <Wd>, <Wn>, #0, #7

and is always the preferred disassembly.

64-bit (sf == 1 && N == 1)

SXTB <Xd>, <Wn>

is equivalent to

[SBFM](#) <Xd>, <Xn>, #0, #7

and is always the preferred disassembly.

Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
- <Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.

Operation

The description of [SBFM](#) gives the operational pseudocode for this instruction.

Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SXTH

Sign Extend Halfword extracts a 16-bit value, sign-extends it to the size of the register, and writes the result to the destination register.

This is an alias of [SBFM](#). This means:

- The encodings in this description are named to match the encodings of [SBFM](#).
- The description of [SBFM](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	0	1	0	0	1	1	0	N	0	0	0	0	0	0	0	0	1	1	1	1	Rn				Rd					
opc									immr							imms															

## 32-bit (sf == 0 && N == 0)

SXTH <Wd>, <Wn>

is equivalent to

[SBFM](#) <Wd>, <Wn>, #0, #15

and is always the preferred disassembly.

## 64-bit (sf == 1 && N == 1)

SXTH <Xd>, <Wn>

is equivalent to

[SBFM](#) <Xd>, <Xn>, #0, #15

and is always the preferred disassembly.

## Assembler Symbols

- |      |  |
|------|--|
| <Wd> | Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field. |
| <Xd> | Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field. |
| <Xn> | Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.      |
| <Wn> | Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.      |

## Operation

The description of [SBFM](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SXTW

Sign Extend Word sign-extends a word to the size of the register, and writes the result to the destination register.

This is an alias of [SBFM](#). This means:

- The encodings in this description are named to match the encodings of [SBFM](#).
- The description of [SBFM](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
1	0	0	1	0	0	1	1	0	1	0	0	0	0	0	0	0	1	1	1	1	1	Rn						Rd					
sf			opc						N	immr						imms																	

## 64-bit

SXTW <Xd>, <Wn>

is equivalent to

[SBFM](#) <Xd>, <Xn>, #0, #31

and is always the preferred disassembly.

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
- <Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.

## Operation

The description of [SBFM](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

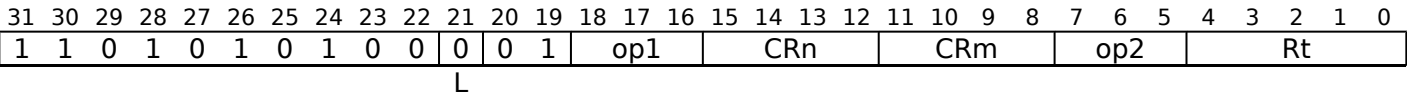
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SYS

System instruction. For more information, see [Op0 equals 0b01, cache maintenance, TLB maintenance, and address translation instructions](#) for the encodings of System instructions.

This instruction is used by the aliases [AT](#), [CFP](#), [CPP](#), [DC](#), [DVP](#), [IC](#), and [TLBI](#).



SYS #<op1>, <Cn>, <Cm>, #<op2>{, <Xt>}

```
AArch64.CheckSystemAccess('01', op1, CRn, CRm, op2, Rt, L);

integer t = UInt(Rt);

integer sys_op1 = UInt(op1);
integer sys_op2 = UInt(op2);
integer sys_crn = UInt(CRn);
integer sys_crm = UInt(CRm);
```

Assembler Symbols

- <op1> Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the "op1" field.
- <Cn> Is a name 'Cn', with 'n' in the range 0 to 15, encoded in the "CRn" field.
- <Cm> Is a name 'Cm', with 'm' in the range 0 to 15, encoded in the "CRm" field.
- <op2> Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the "op2" field.
- <Xt> Is the 64-bit name of the optional general-purpose source register, defaulting to '11111', encoded in the "Rt" field.

Alias Conditions

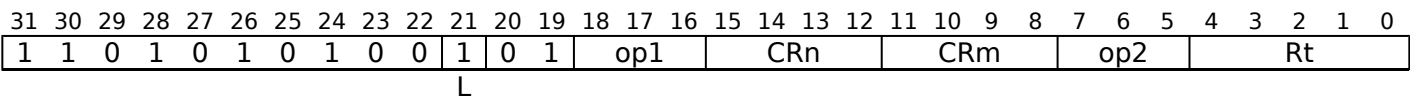
Alias	Is preferred when
<a href="#">AT</a>	CRn == '0111' && CRm == '100x' && <a href="#">SysOp</a> (op1, '0111', CRm, op2) == <a href="#">Sys_AT</a>
<a href="#">CFP</a>	op1 == '011' && CRn == '0111' && CRm == '0011' && op2 == '100'
<a href="#">CPP</a>	op1 == '011' && CRn == '0111' && CRm == '0011' && op2 == '111'
<a href="#">DC</a>	CRn == '0111' && <a href="#">SysOp</a> (op1, '0111', CRm, op2) == <a href="#">Sys_DC</a>
<a href="#">DVP</a>	op1 == '011' && CRn == '0111' && CRm == '0011' && op2 == '101'
<a href="#">IC</a>	CRn == '0111' && <a href="#">SysOp</a> (op1, '0111', CRm, op2) == <a href="#">Sys_IC</a>
<a href="#">TLBI</a>	CRn == '1000' && <a href="#">SysOp</a> (op1, '1000', CRm, op2) == <a href="#">Sys_TLBI</a>

Operation

```
AArch64.SysInstr(1, sys_op1, sys_crn, sys_crm, sys_op2, X[t]);
```

# SYSL

System instruction with result. For more information, see *Op0 equals 0b01, cache maintenance, TLB maintenance, and address translation instructions* for the encodings of System instructions.



SYSL <Xt>, #<op1>, <Cn>, <Cm>, #<op2>

```
AArch64.CheckSystemAccess('01', op1, CRn, CRm, op2, Rt, L);

integer t = UInt(Rt);

integer sys_op1 = UInt(op1);
integer sys_op2 = UInt(op2);
integer sys_crn = UInt(CRn);
integer sys_crm = UInt(CRm);
```

## Assembler Symbols

- <Xt> Is the 64-bit name of the general-purpose destination register, encoded in the "Rt" field.
- <op1> Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the "op1" field.
- <Cn> Is a name 'Cn', with 'n' in the range 0 to 15, encoded in the "CRn" field.
- <Cm> Is a name 'Cm', with 'm' in the range 0 to 15, encoded in the "CRm" field.
- <op2> Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the "op2" field.

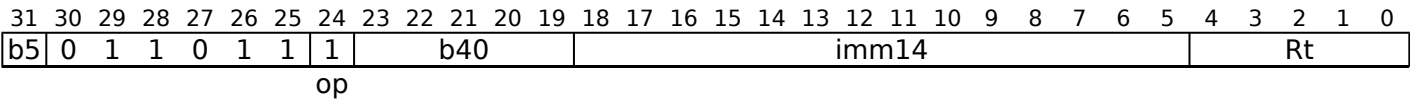
## Operation

```
// No architecturally defined instructions here.
X[t] = AArch64.SysInstrWithResult(1, sys_op1, sys_crn, sys_crm, sys_op2);
```



# TBNZ

Test bit and Branch if Nonzero compares the value of a bit in a general-purpose register with zero, and conditionally branches to a label at a PC-relative offset if the comparison is not equal. It provides a hint that this is not a subroutine call or return. This instruction does not affect condition flags.



TBNZ <R><t>, #<imm>, <label>

```
integer t = UInt(Rt);

integer datasize = if b5 == '1' then 64 else 32;
integer bit_pos = UInt(b5:b40);
bits(64) offset = SignExtend(imm14:'00', 64);
```

## Assembler Symbols

- <R> Is a width specifier, encoded in "b5":
- | b5 | <R> |
|----|-----|
| 0  | W   |
| 1  | X   |
- In assembler source code an 'X' specifier is always permitted, but a 'W' specifier is only permitted when the bit number is less than 32.
- <t> Is the number [0-30] of the general-purpose register to be tested or the name ZR (31), encoded in the "Rt" field.
- <imm> Is the bit number to be tested, in the range 0 to 63, encoded in "b5:b40".
- <label> Is the program label to be conditionally branched to. Its offset from the address of this instruction, in the range +/-32KB, is encoded as "imm14" times 4.

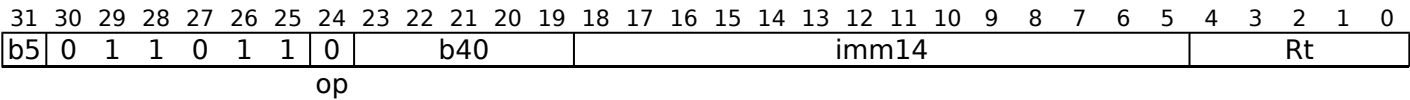
## Operation

```
bits(datasize) operand = X[t];

if operand<bit_pos> == op then
    BranchTo(PC[] + offset, BranchType_DIR, TRUE);
```

# TBZ

Test bit and Branch if Zero compares the value of a test bit with zero, and conditionally branches to a label at a PC-relative offset if the comparison is equal. It provides a hint that this is not a subroutine call or return. This instruction does not affect condition flags.



TBZ <R><t>, #<imm>, <label>

```
integer t = UInt(Rt);

integer datasize = if b5 == '1' then 64 else 32;
integer bit_pos = UInt(b5:b40);
bits(64) offset = SignExtend(imm14:'00', 64);
```

## Assembler Symbols

- <R> Is a width specifier, encoded in "b5":
- | b5 | <R> |
|----|-----|
| 0  | W   |
| 1  | X   |
- In assembler source code an 'X' specifier is always permitted, but a 'W' specifier is only permitted when the bit number is less than 32.
- <t> Is the number [0-30] of the general-purpose register to be tested or the name ZR (31), encoded in the "Rt" field.
- <imm> Is the bit number to be tested, in the range 0 to 63, encoded in "b5:b40".
- <label> Is the program label to be conditionally branched to. Its offset from the address of this instruction, in the range +/-32KB, is encoded as "imm14" times 4.

## Operation

```
bits(datasize) operand = X[t];

if operand<bit_pos> == op then
    BranchTo(PC[] + offset, BranchType_DIR, TRUE);
```

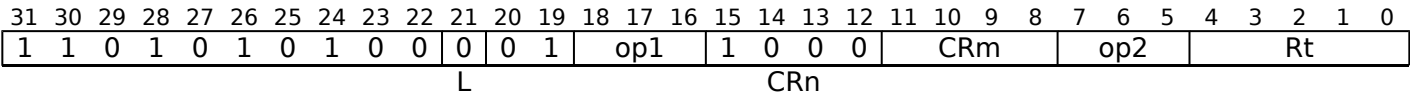
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41  
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

TLBI

TLB Invalidate operation. For more information, see *op0==0b01, cache maintenance, TLB maintenance, and address translation instructions*.

This is an alias of [SYS](#). This means:

- The encodings in this description are named to match the encodings of [SYS](#).
- The description of [SYS](#) gives the operational pseudocode for this instruction.



TLBI [<tlbi\\_op>](#){, [<Xt>](#)}

is equivalent to

[SYS](#) [#<op1>](#), C8, [<Cm>](#), [#<op2>](#){, [<Xt>](#)}

and is the preferred disassembly when `SysOp(op1, '1000', CRm, op2) == Sys_TLBI`.

Assembler Symbols

- <op1>

Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the "op1" field.
- <Cm>

Is a name 'Cm', with 'm' in the range 0 to 15, encoded in the "CRm" field.
- <op2>

Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the "op2" field.
- <tlbi\_op>

Is a TLBI instruction name, as listed for the TLBI system instruction group, encoded in “op1:CRm:op2”:

op1	CRm	op2	<tlbi_op>	Architectural Feature
000	0001	000	VMALLE10S	FEAT_TLBIOS
000	0001	001	VAE10S	FEAT_TLBIOS
000	0001	010	ASIDE10S	FEAT_TLBIOS
000	0001	011	VAAE10S	FEAT_TLBIOS
000	0001	101	VALE10S	FEAT_TLBIOS
000	0001	111	VAALE10S	FEAT_TLBIOS
000	0010	001	RVAE1IS	FEAT_TLBIRANGE
000	0010	011	RVAAE1IS	FEAT_TLBIRANGE
000	0010	101	RVALE1IS	FEAT_TLBIRANGE
000	0010	111	RVAALE1IS	FEAT_TLBIRANGE
000	0011	000	VMALLE1IS	-
000	0011	001	VAE1IS	-
000	0011	010	ASIDE1IS	-
000	0011	011	VAAE1IS	-
000	0011	101	VALE1IS	-
000	0011	111	VAALE1IS	-
000	0101	001	RVAE10S	FEAT_TLBIRANGE
000	0101	011	RVAAE10S	FEAT_TLBIRANGE
000	0101	101	RVALE10S	FEAT_TLBIRANGE
000	0101	111	RVAALE10S	FEAT_TLBIRANGE
000	0110	001	RVAE1	FEAT_TLBIRANGE
000	0110	011	RVAAE1	FEAT_TLBIRANGE
000	0110	101	RVALE1	FEAT_TLBIRANGE
000	0110	111	RVAALE1	FEAT_TLBIRANGE
000	0111	000	VMALLE1	-
000	0111	001	VAE1	-
000	0111	010	ASIDE1	-
000	0111	011	VAAE1	-
000	0111	101	VALE1	-
000	0111	111	VAALE1	-
100	0000	001	IPAS2E1IS	-
100	0000	010	RIPAS2E1IS	FEAT_TLBIRANGE
100	0000	101	IPAS2LE1IS	-
100	0000	110	RIPAS2LE1IS	FEAT_TLBIRANGE
100	0001	000	ALLE20S	FEAT_TLBIOS
100	0001	001	VAE20S	FEAT_TLBIOS
100	0001	100	ALLE10S	FEAT_TLBIOS
100	0001	101	VALE20S	FEAT_TLBIOS
100	0001	110	VMALLS12E10S	FEAT_TLBIOS
100	0010	001	RVAE2IS	FEAT_TLBIRANGE
100	0010	101	RVALE2IS	FEAT_TLBIRANGE
100	0011	000	ALLE2IS	-
100	0011	001	VAE2IS	-
100	0011	100	ALLE1IS	-
100	0011	101	VALE2IS	-
100	0011	110	VMALLS12E1IS	-
100	0100	000	IPAS2E10S	FEAT_TLBIOS
100	0100	001	IPAS2E1	-
100	0100	010	RIPAS2E1	FEAT_TLBIRANGE
100	0100	011	RIPAS2E10S	FEAT_TLBIRANGE
100	0100	100	IPAS2LE10S	FEAT_TLBIOS
100	0100	101	IPAS2LE1	-
100	0100	110	RIPAS2LE1	FEAT_TLBIRANGE
100	0100	111	RIPAS2LE10S	FEAT_TLBIRANGE
100	0101	001	RVAE20S	FEAT_TLBIRANGE
100	0101	101	RVALE20S	FEAT_TLBIRANGE
100	0110	001	RVAE2	FEAT_TLBIRANGE
100	0110	101	RVALE2	FEAT_TLBIRANGE
100	0111	000	ALLE2	-
100	0111	001	VAE2	-
100	0111	100	ALLE1	-
100	0111	101	VALE2	-
100	0111	110	VMALLS12E1	-
110	0001	000	ALLE30S	FEAT_TLBIOS
110	0001	001	VAE30S	FEAT_TLBIOS
110	0001	101	VALE30S	FEAT_TLBIOS
110	0010	001	RVAE3IS	FEAT_TLBIRANGE
110	0010	101	RVALE3IS	FEAT_TLBIRANGE

op1	CRm	op2	<tlbi_op>	Architectural Feature
110	0011	000	ALLE3IS	-
110	0011	001	VAE3IS	-
110	0011	101	VALE3IS	-
110	0101	001	RVAE30S	FEAT_TLBIRANGE
110	0101	101	RVALE30S	FEAT_TLBIRANGE
110	0110	001	RVAE3	FEAT_TLBIRANGE
110	0110	101	RVALE3	FEAT_TLBIRANGE
110	0111	000	ALLE3	-
110	0111	001	VAE3	-
110	0111	101	VALE3	-

<Xt> Is the 64-bit name of the optional general-purpose source register, defaulting to '11111', encoded in the "Rt" field.

## Operation

The description of [SYS](#) gives the operational pseudocode for this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# TSB CSYNC

Trace Synchronization Barrier. This instruction is a barrier that synchronizes the trace operations of instructions. If *FEAT\_TRF* is not implemented, this instruction executes as a NOP.

## System (FEAT\_TRF)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	1	0	0	1	0	1	1	1	1	1
																CRm				op2											

## TSB CSYNC

```
if !HaveSelfHostedTrace() then EndOfInstruction();
```

## Operation

```
TraceSynchronizationBarrier();
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41  
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# TST (immediate)

Test bits (immediate), setting the condition flags and discarding the result

: Rn AND imm.

This is an alias of [ANDS \(immediate\)](#). This means:

- The encodings in this description are named to match the encodings of [ANDS \(immediate\)](#).
  - The description of [ANDS \(immediate\)](#) gives the operational pseudocode for this instruction.
- |    |    |    |    |    |    |    |    |    |    |      |    |    |    |    |    |      |    |    |    |    |    |    |   |   |   |    |   |           |   |   |   |  |
|----|----|----|----|----|----|----|----|----|----|------|----|----|----|----|----|------|----|----|----|----|----|----|---|---|---|----|---|-----------|---|---|---|--|
| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21   | 20 | 19 | 18 | 17 | 16 | 15   | 14 | 13 | 12 | 11 | 10 | 9  | 8 | 7 | 6 | 5  | 4 | 3         | 2 | 1 | 0 |  |
| sf | 1  | 1  | 1  | 0  | 0  | 1  | 0  | 0  | N  | immr |    |    |    |    |    | imms |    |    |    |    |    | Rn |   |   |   |    |   | 1 1 1 1 1 |   |   |   |  |
|    |    |    |    |    |    |    |    |    |    | opc  |    |    |    |    |    |      |    |    |    |    |    |    |   |   |   | Rd |   |           |   |   |   |  |

## 32-bit (sf == 0 && N == 0)

TST <Wn>, #<imm>

is equivalent to

[ANDS](#) WZR, <Wn>, #<imm>

and is always the preferred disassembly.

## 64-bit (sf == 1)

TST <Xn>, #<imm>

is equivalent to

[ANDS](#) XZR, <Xn>, #<imm>

and is always the preferred disassembly.

## Assembler Symbols

- |       |  |
|-------|--|
| <Wn>  | Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.  |
| <Xn>  | Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.  |
| <imm> | For the 32-bit variant: is the bitmask immediate, encoded in "imms:immr".<br>For the 64-bit variant: is the bitmask immediate, encoded in "N:imms:immr". |

## Operation

The description of [ANDS \(immediate\)](#) gives the operational pseudocode for this instruction.

# TST (shifted register)

Test (shifted register) performs a bitwise AND operation on a register value and an optionally-shifted register value. It updates the condition flags based on the result, and discards the result.

This is an alias of [ANDS \(shifted register\)](#). This means:

- The encodings in this description are named to match the encodings of [ANDS \(shifted register\)](#).
  - The description of [ANDS \(shifted register\)](#) gives the operational pseudocode for this instruction.
- |     |    |    |    |    |    |    |    |       |    |    |    |    |    |    |    |      |    |    |    |    |    |    |   |   |   |   |   |    |   |   |   |  |
|-----|----|----|----|----|----|----|----|-------|----|----|----|----|----|----|----|------|----|----|----|----|----|----|---|---|---|---|---|----|---|---|---|--|
| 31  | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23    | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15   | 14 | 13 | 12 | 11 | 10 | 9  | 8 | 7 | 6 | 5 | 4 | 3  | 2 | 1 | 0 |  |
| sf  | 1  | 1  | 0  | 1  | 0  | 1  | 0  | shift | 0  | Rm |    |    |    |    |    | imm6 |    |    |    |    |    | Rn |   |   | 1 | 1 | 1 | 1  | 1 |   |   |  |
| opc |    |    |    |    |    |    |    | N     |    |    |    |    |    |    |    |      |    |    |    |    |    |    |   |   |   |   |   | Rd |   |   |   |  |

## 32-bit (sf == 0)

TST <Wn>, <Wm>{, <shift> #<amount>}

is equivalent to

[ANDS](#) WZR, <Wn>, <Wm>{, <shift> #<amount>}

and is always the preferred disassembly.

## 64-bit (sf == 1)

TST <Xn>, <Xm>{, <shift> #<amount>}

is equivalent to

[ANDS](#) XZR, <Xn>, <Xm>{, <shift> #<amount>}

and is always the preferred disassembly.

## Assembler Symbols

- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <shift> Is the optional shift to be applied to the final source, defaulting to LSL and encoded in "shift":
- | shift | <shift> |
|-------|---------|
| 00    | LSL     |
| 01    | LSR     |
| 10    | ASR     |
| 11    | ROR     |
- <amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.
- For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field,

## Operation

The description of [ANDS \(shifted register\)](#) gives the operational pseudocode for this instruction.



## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# UBFIZ

Unsigned Bitfield Insert in Zeros copies a bitfield of <width> bits from the least significant bits of the source register to bit position <lsb> of the destination register, setting the destination bits above and below the bitfield to zero.

This is an alias of [UBFM](#). This means:

- The encodings in this description are named to match the encodings of [UBFM](#).
- The description of [UBFM](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	1	0	1	0	0	1	1	0	N	immr						imms						Rn						Rd			
opc																															

## 32-bit (sf == 0 && N == 0)

UBFIZ <Wd>, <Wn>, #<lsb>, #<width>

is equivalent to

UBFM <Wd>, <Wn>, #(-<lsb> MOD 32), #(<width>-1)

and is the preferred disassembly when `UInt(imms) < UInt(immr)`.

## 64-bit (sf == 1 && N == 1)

UBFIZ <Xd>, <Xn>, #<lsb>, #<width>

is equivalent to

UBFM <Xd>, <Xn>, #(-<lsb> MOD 64), #(<width>-1)

and is the preferred disassembly when `UInt(imms) < UInt(immr)`.

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
- <lsb> For the 32-bit variant: is the bit number of the lsb of the destination bitfield, in the range 0 to 31.  
For the 64-bit variant: is the bit number of the lsb of the destination bitfield, in the range 0 to 63.
- <width> For the 32-bit variant: is the width of the bitfield, in the range 1 to 32-<lsb>.  
For the 64-bit variant: is the width of the bitfield, in the range 1 to 64-<lsb>.

## Operation

The description of [UBFM](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.



UBFM

Unsigned Bitfield Move is usually accessed via one of its aliases, which are always preferred for disassembly.

If <imms> is greater than or equal to <immr>, this copies a bitfield of (<imms>-<immr>+1) bits starting from bit position <immr> in the source register to the least significant bits of the destination register.

If <imms> is less than <immr>, this copies a bitfield of (<imms>+1) bits from the least significant bits of the source register to bit position (regsize-<immr>) of the destination register, where regsize is the destination register size of 32 or 64 bits.

In both cases the destination bits below and above the bitfield are set to zero.

This instruction is used by the aliases [LSL \(immediate\)](#), [LSR \(immediate\)](#), [UBFIZ](#), [UBFX](#), [UXTB](#), and [UXTH](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	1	0	1	0	0	1	1	0	N	immr						imms						Rn						Rd			
opc																															

32-bit (sf == 0 && N == 0)

UBFM <Wd>, <Wn>, #<immr>, #<imms>

64-bit (sf == 1 && N == 1)

UBFM <Xd>, <Xn>, #<immr>, #<imms>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer datasize = if sf == '1' then 64 else 32;

integer R;
bits(datasize) wmask;
bits(datasize) tmask;

if sf == '1' && N != '1' then UNDEFINED;
if sf == '0' && (N != '0' || immr<5> != '0' || imms<5> != '0') then UNDEFINED;

R = UInt(immr);
(wmask, tmask) = DecodeBitMasks(N, imms, immr, FALSE);
```

Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
- <immr> For the 32-bit variant: is the right rotate amount, in the range 0 to 31, encoded in the "immr" field.  
For the 64-bit variant: is the right rotate amount, in the range 0 to 63, encoded in the "immr" field.
- <imms> For the 32-bit variant: is the leftmost bit number to be moved from the source, in the range 0 to 31, encoded in the "imms" field.  
For the 64-bit variant: is the leftmost bit number to be moved from the source, in the range 0 to 63, encoded in the "imms" field.

Alias Conditions

Alias	Of variant	Is preferred when
<a href="#">LSL (immediate)</a>	32-bit	imms != '011111' && imms + 1 == immr
<a href="#">LSL (immediate)</a>	64-bit	imms != '111111' && imms + 1 == immr
<a href="#">LSR (immediate)</a>	32-bit	imms == '011111'

Alias	Of variant	Is preferred when
<a href="#">LSR (immediate)</a>	64-bit	<code>imms == '111111'</code>
<a href="#">UBFIZ</a>		<code>UInt(imms) &lt; UInt(immr)</code>
<a href="#">UBFX</a>		<code>BFXPreferred(sf, opc&lt;1&gt;, imms, immr)</code>
<a href="#">UXTB</a>		<code>immr == '000000' &amp;&amp; imms == '000111'</code>
<a href="#">UXTH</a>		<code>immr == '000000' &amp;&amp; imms == '001111'</code>

## Operation

```
bits(datasize) src = X[n];

// perform bitfield move on low bits
bits(datasize) bot = ROR(src, R) AND wmask;

// combine extension bits and result bits
X[d] = bot AND tmask;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# UBFX

Unsigned Bitfield Extract copies a bitfield of <width> bits starting from bit position <lsb> in the source register to the least significant bits of the destination register, and sets destination bits above the bitfield to zero.

This is an alias of [UBFM](#). This means:

- The encodings in this description are named to match the encodings of [UBFM](#).
- The description of [UBFM](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	1	0	1	0	0	1	1	0	N	immr						imms						Rn						Rd			
opc																															

## 32-bit (sf == 0 && N == 0)

UBFX <Wd>, <Wn>, #<lsb>, #<width>

is equivalent to

UBFM <Wd>, <Wn>, #<lsb>, #(<lsb>+<width>-1)

and is the preferred disassembly when `BFXPreferred(sf, opc<1>, imms, immr)`.

## 64-bit (sf == 1 && N == 1)

UBFX <Xd>, <Xn>, #<lsb>, #<width>

is equivalent to

UBFM <Xd>, <Xn>, #<lsb>, #(<lsb>+<width>-1)

and is the preferred disassembly when `BFXPreferred(sf, opc<1>, imms, immr)`.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
<lsb>	For the 32-bit variant: is the bit number of the lsb of the source bitfield, in the range 0 to 31. For the 64-bit variant: is the bit number of the lsb of the source bitfield, in the range 0 to 63.
<width>	For the 32-bit variant: is the width of the bitfield, in the range 1 to 32-<lsb>. For the 64-bit variant: is the width of the bitfield, in the range 1 to 64-<lsb>.

## Operation

The description of [UBFM](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.



# UDF

Permanently Undefined generates an Undefined Instruction exception (ESR\_ELx.EC = 0b0000000). The encodings for UDF used in this section are defined as permanently UNDEFINED in the Armv8-A architecture.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	imm16															

UDF #<imm>

```
// The imm16 field is ignored by hardware.  
UNDEFINED;
```

## Assembler Symbols

<imm> is a 16-bit unsigned immediate, in the range 0 to 65535, encoded in the "imm16" field. The PE ignores the value of this constant.

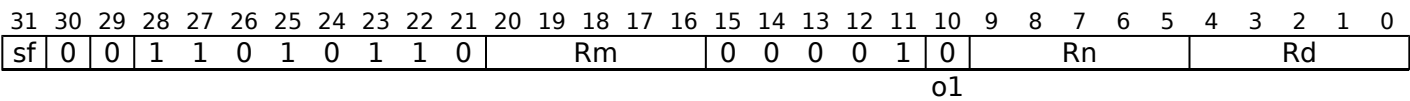
## Operation

```
// No operation.
```



# UDIV

Unsigned Divide divides an unsigned integer register value by another unsigned integer register value, and writes the result to the destination register. The condition flags are not affected.



## 32-bit (sf == 0)

```
UDIV <Wd>, <Wn>, <Wm>
```

## 64-bit (sf == 1)

```
UDIV <Xd>, <Xn>, <Xm>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.

## Operation

```
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = X[m];
integer result;

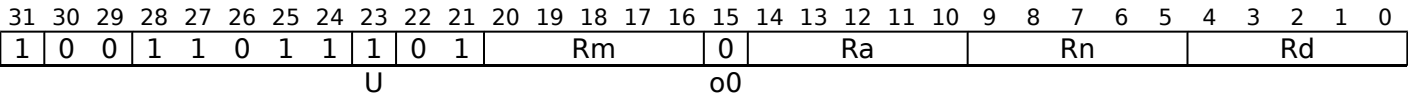
if IsZero(operand2) then
    result = 0;
else
    result = RoundTowardsZero(Real(Int(operand1, TRUE)) / Real(Int(operand2, TRUE)));

X[d] = result<datasize-1:0>;
```

# UMADDL

Unsigned Multiply-Add Long multiplies two 32-bit register values, adds a 64-bit register value, and writes the result to the 64-bit destination register.

This instruction is used by the alias [UMULL](#).



UMADDL <Xd>, <Wn>, <Wm>, <Xa>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer a = UInt(Ra);
```

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.
- <Xa> Is the 64-bit name of the third general-purpose source register holding the addend, encoded in the "Ra" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">UMULL</a>	Ra == '11111'

## Operation

```
bits(32) operand1 = X[n];
bits(32) operand2 = X[m];
bits(64) operand3 = X[a];

integer result;

result = Int(operand3, TRUE) + (Int(operand1, TRUE) * Int(operand2, TRUE));

X[d] = result<63:0>;
```

## Operational information

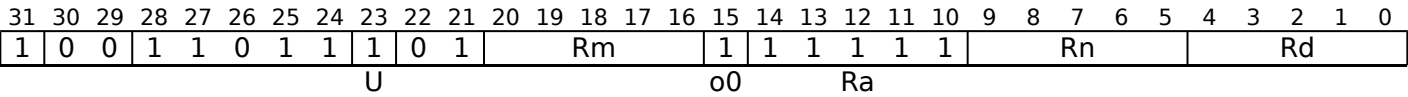
- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# UMNEGL

Unsigned Multiply-Negate Long multiplies two 32-bit register values, negates the product, and writes the result to the 64-bit destination register.

This is an alias of [UMSUBL](#). This means:

- The encodings in this description are named to match the encodings of [UMSUBL](#).
- The description of [UMSUBL](#) gives the operational pseudocode for this instruction.



UMNEGL <Xd>, <Wn>, <Wm>

is equivalent to

[UMSUBL](#) <Xd>, <Wn>, <Wm>, XZR

and is always the preferred disassembly.

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.

## Operation

The description of [UMSUBL](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

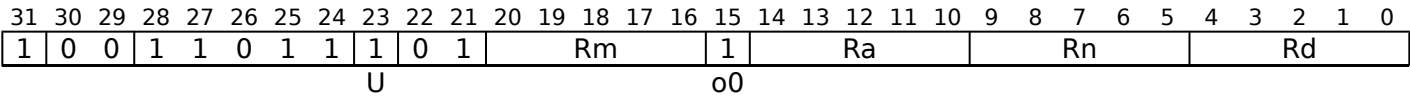
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# UMSUBL

Unsigned Multiply-Subtract Long multiplies two 32-bit register values, subtracts the product from a 64-bit register value, and writes the result to the 64-bit destination register.

This instruction is used by the alias [UMNEGL](#).



UMSUBL <Xd>, <Wn>, <Wm>, <Xa>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer a = UInt(Ra);
```

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.
- <Xa> Is the 64-bit name of the third general-purpose source register holding the minuend, encoded in the "Ra" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">UMNEGL</a>	Ra == '11111'

## Operation

```
bits(32) operand1 = X[n];
bits(32) operand2 = X[m];
bits(64) operand3 = X[a];

integer result;

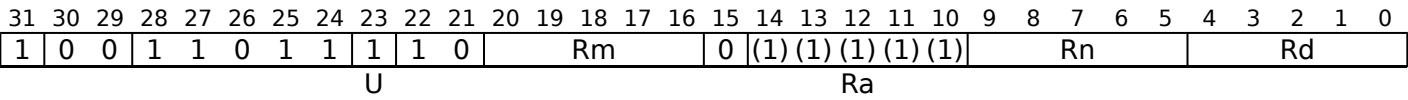
result = Int(operand3, TRUE) - (Int(operand1, TRUE) * Int(operand2, TRUE));
X[d] = result<63:0>;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# UMULH

Unsigned Multiply High multiplies two 64-bit register values, and writes bits[127:64] of the 128-bit result to the 64-bit destination register.



UMULH <Xd>, <Xn>, <Xm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
```

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.

## Operation

```
bits(64) operand1 = X[n];
bits(64) operand2 = X[m];

integer result;

result = Int(operand1, TRUE) * Int(operand2, TRUE);

X[d] = result<127:64>;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# UMULL

Unsigned Multiply Long multiplies two 32-bit register values, and writes the result to the 64-bit destination register.

This is an alias of [UMADDL](#). This means:

- The encodings in this description are named to match the encodings of [UMADDL](#).
- The description of [UMADDL](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	1	0	1	1	1	0	1	Rm				0	1	1	1	1	1	Rn				Rd						
U										o0				Ra																	

UMULL <Xd>, <Wn>, <Wm>

is equivalent to

[UMADDL](#) <Xd>, <Wn>, <Wm>, XZR

and is always the preferred disassembly.

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.

## Operation

The description of [UMADDL](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UXTB

Unsigned Extend Byte extracts an 8-bit value from a register, zero-extends it to the size of the register, and writes the result to the destination register.

This is an alias of [UBFM](#). This means:

- The encodings in this description are named to match the encodings of [UBFM](#).
- The description of [UBFM](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	Rn				Rd					
sf			opc						N		immr				imms																

32-bit

UXTB <Wd>, <Wn>

is equivalent to

[UBFM](#) <Wd>, <Wn>, #0, #7

and is always the preferred disassembly.

Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.

Operation

The description of [UBFM](#) gives the operational pseudocode for this instruction.

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# UXTH

Unsigned Extend Halfword extracts a 16-bit value from a register, zero-extends it to the size of the register, and writes the result to the destination register.

This is an alias of [UBFM](#). This means:

- The encodings in this description are named to match the encodings of [UBFM](#).
- The description of [UBFM](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	Rn				Rd					
sf		opc						N		immr				imms																	

## 32-bit

UXTH <Wd>, <Wn>

is equivalent to

[UBFM](#) <Wd>, <Wn>, #0, #15

and is always the preferred disassembly.

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.

## Operation

The description of [UBFM](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



WFE

Wait For Event is a hint instruction that indicates that the PE can enter a low-power state and remain there until a wakeup event occurs. Wakeup events include the event signaled as a result of executing the SEV instruction on any PE in the multiprocessor system. For more information, see *Wait For Event mechanism and Send event*.

As described in *Wait For Event mechanism and Send event*, the execution of a WFE instruction that would otherwise cause entry to a low-power state can be trapped to a higher Exception level. See:

- *Traps to EL1 of EL0 execution of WFE and WFI instructions.*
- *Traps to EL2 of Non-secure EL0 and EL1 execution of WFE and WFI instructions.*
- *Traps to EL3 of EL2, EL1, and EL0 execution of WFE and WFI instructions.*

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	1	0	1	1	1	1	1
																CRm				op2											

WFE

```
// Empty.
```

Operation

```
Hint_WFE(-1, WFxType_WFE);
```

WFET

Wait For Event with Timeout is a hint instruction that indicates that the PE can enter a low-power state and remain there until either a local timeout event or a wakeup event occurs. Wakeup events include the event signaled as a result of executing the SEV instruction on any PE in the multiprocessor system. For more information, see [Wait For Event mechanism and Send event](#).

As described in [Wait For Event mechanism and Send event](#), the execution of a WFET instruction that would otherwise cause entry to a low-power state can be trapped to a higher Exception level. See:

- [Traps to EL1 of EL0 execution of WFE and WFI instructions](#).
- [Traps to EL2 of Non-secure EL0 and EL1 execution of WFE and WFI instructions](#).
- [Traps to EL3 of EL2, EL1, and EL0 execution of WFE and WFI instructions](#).

System  
(FEAT\_WFXT)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0				Rd
																														op2	

WFET <Xt>

```
if !HaveFeatWFXT() then UNDEFINED;

integer d = UInt(Rd);
```

Assembler Symbols

<Xt> Is the 64-bit name of the general-purpose source register, encoded in the "Rd" field.

Operation

```
bits(64) operand = X[d];
integer localtimeout = UInt(operand);

if Halted() && ConstrainUnpredictableBool(Unpredictable_WFXTDEBUG) then
    EndOfInstruction();

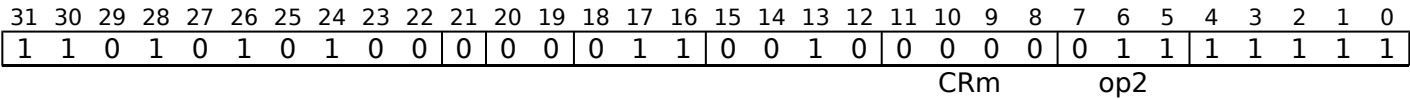
Hint_WFE(localtimeout, WFXType_WFET);
```

WFI

Wait For Interrupt is a hint instruction that indicates that the PE can enter a low-power state and remain there until a wakeup event occurs. For more information, see *Wait For Interrupt*.

As described in *Wait For Interrupt*, the execution of a WFI instruction that would otherwise cause entry to a low-power state can be trapped to a higher Exception level. See:

- *Traps to EL1 of EL0 execution of WFE and WFI instructions.*
- *Traps to EL2 of Non-secure EL0 and EL1 execution of WFE and WFI instructions.*
- *Traps to EL3 of EL2, EL1, and EL0 execution of WFE and WFI instructions.*



WFI

```
// Empty.
```

Operation

```
Hint_WFI(-1, WFxType_WFI);
```

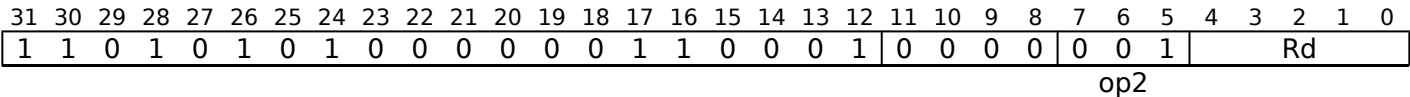
WFIT

Wait For Interrupt with Timeout is a hint instruction that indicates that the PE can enter a low-power state and remain there until either a local timeout event or a wakeup event occurs. For more information, see [Wait For Interrupt](#).

As described in [Wait For Interrupt](#), the execution of a WFIT instruction that would otherwise cause entry to a low-power state can be trapped to a higher Exception level. See:

- [Traps to EL1 of EL0 execution of WFE and WFI instructions](#).
- [Traps to EL2 of Non-secure EL0 and EL1 execution of WFE and WFI instructions](#).
- [Traps to EL3 of EL2, EL1, and EL0 execution of WFE and WFI instructions](#).

System  
(FEAT\_WFxT)



WFIT <Xt>

```
if !HaveFeatWFxT() then UNDEFINED;
integer d = UInt(Rd);
```

Assembler Symbols

<Xt> Is the 64-bit name of the general-purpose source register, encoded in the "Rd" field.

Operation

```
bits(64) operand = X[d];
integer localtimeout = UInt(operand);

if Halted() && ConstrainUnpredictableBool(Unpredictable_WFxTDEBUG) then
    EndOfInstruction();

Hint_WFI(localtimeout, WFxType_WFIT);
```

XAFLAG

Convert floating-point condition flags from external format to Arm format. This instruction converts the state of the PSTATE.{N,Z,C,V} flags from an alternative representation required by some software to a form representing the result of an Arm floating-point scalar compare instruction.

System  
(FEAT\_FlagM2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	(0)	(0)	(0)	(0)	0	0	1	1	1	1	1	1

CRm

XAFLAG

```
if !HaveFlagFormatExt() then UNDEFINED;
```

Operation

```
bit N = NOT(PSTATE.C) AND NOT(PSTATE.Z);
bit Z = PSTATE.Z AND PSTATE.C;
bit C = PSTATE.C OR PSTATE.Z;
bit V = NOT(PSTATE.C) AND PSTATE.Z;

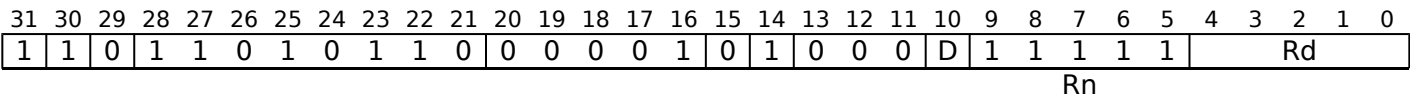
PSTATE.N = N;
PSTATE.Z = Z;
PSTATE.C = C;
PSTATE.V = V;
```

XPACD, XPACI, XPACLRI

Strip Pointer Authentication Code. This instruction removes the pointer authentication code from an address. The address is in the specified general-purpose register for XPACI and XPACD, and is in LR for XPACLRI. The XPACD instruction is used for data addresses, and XPACI and XPACLRI are used for instruction addresses.

It has encodings from 2 classes: [Integer](#) and [System](#)

Integer  
(FEAT\_PAuth)



XPACD (D == 1)

XPACD <Xd>

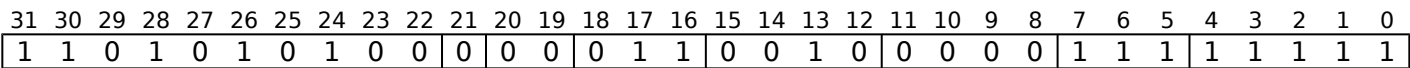
XPACI (D == 0)

XPACI <Xd>

```
boolean data = (D == '1');
integer d = UInt(Rd);

if !HavePACExt() then
    UNDEFINED;
```

System  
(FEAT\_PAuth)



XPACLRI

```
integer d = 30;
boolean data = FALSE;
```

Assembler Symbols

<Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.

Operation

```
if HavePACExt() then
    X[d] = Strip(X[d], data);
```

YIELD

YIELD is a hint instruction. Software with a multithreading capability can use a YIELD instruction to indicate to the PE that it is performing a task, for example a spin-lock, that could be swapped out to improve overall system performance. The PE can use this hint to suspend and resume multiple software threads if it supports the capability.

For more information about the recommended use of this instruction, see [The YIELD instruction](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	1	1	1	1	1
																CRm				op2											

YIELD

```
// Empty.
```

Operation

```
Hint_Yield();
```

## A64 -- SIMD and Floating-point Instructions (alphabetic order)

[ABS](#): Absolute value (vector).

[ADD \(vector\)](#): Add (vector).

[ADDHN, ADDHN2](#): Add returning High Narrow.

[ADDP \(scalar\)](#): Add Pair of elements (scalar).

[ADDP \(vector\)](#): Add Pairwise (vector).

[ADDV](#): Add across Vector.

[AESD](#): AES single round decryption.

[AESE](#): AES single round encryption.

[AESIMC](#): AES inverse mix columns.

[AESMC](#): AES mix columns.

[AND \(vector\)](#): Bitwise AND (vector).

[BCAX](#): Bit Clear and XOR.

[BFCVT](#): Floating-point convert from single-precision to BFloat16 format (scalar).

[BFCVTN, BFCVTN2](#): Floating-point convert from single-precision to BFloat16 format (vector).

[BFDOT \(by element\)](#): BFloat16 floating-point dot product (vector, by element).

[BFDOT \(vector\)](#): BFloat16 floating-point dot product (vector).

[BFMLALB, BFMLALT \(by element\)](#): BFloat16 floating-point widening multiply-add long (by element).

[BFMLALB, BFMLALT \(vector\)](#): BFloat16 floating-point widening multiply-add long (vector).

[BFMMLA](#): BFloat16 floating-point matrix multiply-accumulate into 2x2 matrix.

[BIC \(vector, immediate\)](#): Bitwise bit Clear (vector, immediate).

[BIC \(vector, register\)](#): Bitwise bit Clear (vector, register).

[BIF](#): Bitwise Insert if False.

[BIT](#): Bitwise Insert if True.

[BSL](#): Bitwise Select.

[CLS \(vector\)](#): Count Leading Sign bits (vector).

[CLZ \(vector\)](#): Count Leading Zero bits (vector).

[CMEQ \(register\)](#): Compare bitwise Equal (vector).

[CMEQ \(zero\)](#): Compare bitwise Equal to zero (vector).

[CMGE \(register\)](#): Compare signed Greater than or Equal (vector).

[CMGE \(zero\)](#): Compare signed Greater than or Equal to zero (vector).

[CMGT \(register\)](#): Compare signed Greater than (vector).

[CMGT \(zero\)](#): Compare signed Greater than zero (vector).

[CMHI \(register\)](#): Compare unsigned Higher (vector).

[CMHS \(register\)](#): Compare unsigned Higher or Same (vector).



[CMLE \(zero\)](#): Compare signed Less than or Equal to zero (vector).

[CMLT \(zero\)](#): Compare signed Less than zero (vector).

[CMTST](#): Compare bitwise Test bits nonzero (vector).

[CNT](#): Population Count per byte.

[DUP \(element\)](#): Duplicate vector element to vector or scalar.

[DUP \(general\)](#): Duplicate general-purpose register to vector.

[EOR \(vector\)](#): Bitwise Exclusive OR (vector).

[EOR3](#): Three-way Exclusive OR.

[EXT](#): Extract vector from pair of vectors.

[FABD](#): Floating-point Absolute Difference (vector).

[FABS \(scalar\)](#): Floating-point Absolute value (scalar).

[FABS \(vector\)](#): Floating-point Absolute value (vector).

[FACGE](#): Floating-point Absolute Compare Greater than or Equal (vector).

[FACGT](#): Floating-point Absolute Compare Greater than (vector).

[FADD \(scalar\)](#): Floating-point Add (scalar).

[FADD \(vector\)](#): Floating-point Add (vector).

[FADDP \(scalar\)](#): Floating-point Add Pair of elements (scalar).

[FADDP \(vector\)](#): Floating-point Add Pairwise (vector).

[FCADD](#): Floating-point Complex Add.

[FCCMP](#): Floating-point Conditional quiet Compare (scalar).

[FCCMPE](#): Floating-point Conditional signaling Compare (scalar).

[FCMEQ \(register\)](#): Floating-point Compare Equal (vector).

[FCMEQ \(zero\)](#): Floating-point Compare Equal to zero (vector).

[FCMGE \(register\)](#): Floating-point Compare Greater than or Equal (vector).

[FCMGE \(zero\)](#): Floating-point Compare Greater than or Equal to zero (vector).

[FCMGT \(register\)](#): Floating-point Compare Greater than (vector).

[FCMGT \(zero\)](#): Floating-point Compare Greater than zero (vector).

[FCMLA](#): Floating-point Complex Multiply Accumulate.

[FCMLA \(by element\)](#): Floating-point Complex Multiply Accumulate (by element).

[FCMLE \(zero\)](#): Floating-point Compare Less than or Equal to zero (vector).

[FCMLT \(zero\)](#): Floating-point Compare Less than zero (vector).

[FCMP](#): Floating-point quiet Compare (scalar).

[FCMPE](#): Floating-point signaling Compare (scalar).

[FCSEL](#): Floating-point Conditional Select (scalar).

[FCVT](#): Floating-point Convert precision (scalar).

[FCVTAS \(scalar\)](#): Floating-point Convert to Signed integer, rounding to nearest with ties to Away (scalar).

[FCVTAS \(vector\)](#): Floating-point Convert to Signed integer, rounding to nearest with ties to Away (vector).

[FCVTAU \(scalar\)](#): Floating-point Convert to Unsigned integer, rounding to nearest with ties to Away (scalar).

[FCVTAU \(vector\)](#): Floating-point Convert to Unsigned integer, rounding to nearest with ties to Away (vector).

[FCVTL, FCVTL2](#): Floating-point Convert to higher precision Long (vector).

[FCVTMS \(scalar\)](#): Floating-point Convert to Signed integer, rounding toward Minus infinity (scalar).

[FCVTMS \(vector\)](#): Floating-point Convert to Signed integer, rounding toward Minus infinity (vector).

[FCVTMU \(scalar\)](#): Floating-point Convert to Unsigned integer, rounding toward Minus infinity (scalar).

[FCVTMU \(vector\)](#): Floating-point Convert to Unsigned integer, rounding toward Minus infinity (vector).

[FCVTN, FCVTN2](#): Floating-point Convert to lower precision Narrow (vector).

[FCVTNS \(scalar\)](#): Floating-point Convert to Signed integer, rounding to nearest with ties to even (scalar).

[FCVTNS \(vector\)](#): Floating-point Convert to Signed integer, rounding to nearest with ties to even (vector).

[FCVTNU \(scalar\)](#): Floating-point Convert to Unsigned integer, rounding to nearest with ties to even (scalar).

[FCVTNU \(vector\)](#): Floating-point Convert to Unsigned integer, rounding to nearest with ties to even (vector).

[FCVTPS \(scalar\)](#): Floating-point Convert to Signed integer, rounding toward Plus infinity (scalar).

[FCVTPS \(vector\)](#): Floating-point Convert to Signed integer, rounding toward Plus infinity (vector).

[FCVTPU \(scalar\)](#): Floating-point Convert to Unsigned integer, rounding toward Plus infinity (scalar).

[FCVTPU \(vector\)](#): Floating-point Convert to Unsigned integer, rounding toward Plus infinity (vector).

[FCVTXN, FCVTXN2](#): Floating-point Convert to lower precision Narrow, rounding to odd (vector).

[FCVTZS \(scalar, fixed-point\)](#): Floating-point Convert to Signed fixed-point, rounding toward Zero (scalar).

[FCVTZS \(scalar, integer\)](#): Floating-point Convert to Signed integer, rounding toward Zero (scalar).

[FCVTZS \(vector, fixed-point\)](#): Floating-point Convert to Signed fixed-point, rounding toward Zero (vector).

[FCVTZS \(vector, integer\)](#): Floating-point Convert to Signed integer, rounding toward Zero (vector).

[FCVTZU \(scalar, fixed-point\)](#): Floating-point Convert to Unsigned fixed-point, rounding toward Zero (scalar).

[FCVTZU \(scalar, integer\)](#): Floating-point Convert to Unsigned integer, rounding toward Zero (scalar).

[FCVTZU \(vector, fixed-point\)](#): Floating-point Convert to Unsigned fixed-point, rounding toward Zero (vector).

[FCVTZU \(vector, integer\)](#): Floating-point Convert to Unsigned integer, rounding toward Zero (vector).

[FDIV \(scalar\)](#): Floating-point Divide (scalar).

[FDIV \(vector\)](#): Floating-point Divide (vector).

[FJCVTZS](#): Floating-point Javascript Convert to Signed fixed-point, rounding toward Zero.

[FMADD](#): Floating-point fused Multiply-Add (scalar).

[FMAX \(scalar\)](#): Floating-point Maximum (scalar).

[FMAX \(vector\)](#): Floating-point Maximum (vector).

[FMAXNM \(scalar\)](#): Floating-point Maximum Number (scalar).

[FMAXNM \(vector\)](#): Floating-point Maximum Number (vector).

[FMAXNMP \(scalar\)](#): Floating-point Maximum Number of Pair of elements (scalar).

[FMAXNMP \(vector\)](#): Floating-point Maximum Number Pairwise (vector).

[FMAXNMV](#): Floating-point Maximum Number across Vector.

[FMAXP \(scalar\)](#): Floating-point Maximum of Pair of elements (scalar).

[FMAXP \(vector\)](#): Floating-point Maximum Pairwise (vector).

[FMAXV](#): Floating-point Maximum across Vector.

[FMIN \(scalar\)](#): Floating-point Minimum (scalar).

[FMIN \(vector\)](#): Floating-point minimum (vector).

[FMINNM \(scalar\)](#): Floating-point Minimum Number (scalar).

[FMINNM \(vector\)](#): Floating-point Minimum Number (vector).

[FMINNMP \(scalar\)](#): Floating-point Minimum Number of Pair of elements (scalar).

[FMINNMP \(vector\)](#): Floating-point Minimum Number Pairwise (vector).

[FMINNMV](#): Floating-point Minimum Number across Vector.

[FMINP \(scalar\)](#): Floating-point Minimum of Pair of elements (scalar).

[FMINP \(vector\)](#): Floating-point Minimum Pairwise (vector).

[FMINV](#): Floating-point Minimum across Vector.

[FMLA \(by element\)](#): Floating-point fused Multiply-Add to accumulator (by element).

[FMLA \(vector\)](#): Floating-point fused Multiply-Add to accumulator (vector).

[FMLAL, FMLAL2 \(by element\)](#): Floating-point fused Multiply-Add Long to accumulator (by element).

[FMLAL, FMLAL2 \(vector\)](#): Floating-point fused Multiply-Add Long to accumulator (vector).

[FMLS \(by element\)](#): Floating-point fused Multiply-Subtract from accumulator (by element).

[FMLS \(vector\)](#): Floating-point fused Multiply-Subtract from accumulator (vector).

[FMLS, FMLSL2 \(by element\)](#): Floating-point fused Multiply-Subtract Long from accumulator (by element).

[FMLS, FMLSL2 \(vector\)](#): Floating-point fused Multiply-Subtract Long from accumulator (vector).

[FMOV \(general\)](#): Floating-point Move to or from general-purpose register without conversion.

[FMOV \(register\)](#): Floating-point Move register without conversion.

[FMOV \(scalar, immediate\)](#): Floating-point move immediate (scalar).

[FMOV \(vector, immediate\)](#): Floating-point move immediate (vector).

[FMSUB](#): Floating-point Fused Multiply-Subtract (scalar).

[FMUL \(by element\)](#): Floating-point Multiply (by element).

[FMUL \(scalar\)](#): Floating-point Multiply (scalar).

[FMUL \(vector\)](#): Floating-point Multiply (vector).

[FMULX](#): Floating-point Multiply extended.

[FMULX \(by element\)](#): Floating-point Multiply extended (by element).

[FNEG \(scalar\)](#): Floating-point Negate (scalar).

[FNEG \(vector\)](#): Floating-point Negate (vector).

[FNMADD](#): Floating-point Negated fused Multiply-Add (scalar).

[FNMSUB](#): Floating-point Negated fused Multiply-Subtract (scalar).

[FNMUL \(scalar\)](#): Floating-point Multiply-Negate (scalar).

[FRECPE](#): Floating-point Reciprocal Estimate.

[FRECPS](#): Floating-point Reciprocal Step.

[FRECPX](#): Floating-point Reciprocal exponent (scalar).

[FRINT32X \(scalar\)](#): Floating-point Round to 32-bit Integer, using current rounding mode (scalar).

[FRINT32X \(vector\)](#): Floating-point Round to 32-bit Integer, using current rounding mode (vector).

[FRINT32Z \(scalar\)](#): Floating-point Round to 32-bit Integer toward Zero (scalar).

[FRINT32Z \(vector\)](#): Floating-point Round to 32-bit Integer toward Zero (vector).

[FRINT64X \(scalar\)](#): Floating-point Round to 64-bit Integer, using current rounding mode (scalar).

[FRINT64X \(vector\)](#): Floating-point Round to 64-bit Integer, using current rounding mode (vector).

[FRINT64Z \(scalar\)](#): Floating-point Round to 64-bit Integer toward Zero (scalar).

[FRINT64Z \(vector\)](#): Floating-point Round to 64-bit Integer toward Zero (vector).

[FRINTA \(scalar\)](#): Floating-point Round to Integral, to nearest with ties to Away (scalar).

[FRINTA \(vector\)](#): Floating-point Round to Integral, to nearest with ties to Away (vector).

[FRINTI \(scalar\)](#): Floating-point Round to Integral, using current rounding mode (scalar).

[FRINTI \(vector\)](#): Floating-point Round to Integral, using current rounding mode (vector).

[FRINTM \(scalar\)](#): Floating-point Round to Integral, toward Minus infinity (scalar).

[FRINTM \(vector\)](#): Floating-point Round to Integral, toward Minus infinity (vector).

[FRINTN \(scalar\)](#): Floating-point Round to Integral, to nearest with ties to even (scalar).

[FRINTN \(vector\)](#): Floating-point Round to Integral, to nearest with ties to even (vector).

[FRINTP \(scalar\)](#): Floating-point Round to Integral, toward Plus infinity (scalar).

[FRINTP \(vector\)](#): Floating-point Round to Integral, toward Plus infinity (vector).

[FRINTX \(scalar\)](#): Floating-point Round to Integral exact, using current rounding mode (scalar).

[FRINTX \(vector\)](#): Floating-point Round to Integral exact, using current rounding mode (vector).

[FRINTZ \(scalar\)](#): Floating-point Round to Integral, toward Zero (scalar).

[FRINTZ \(vector\)](#): Floating-point Round to Integral, toward Zero (vector).

[FRSQRT](#): Floating-point Reciprocal Square Root Estimate.

[FRSQRTS](#): Floating-point Reciprocal Square Root Step.

[FSQRT \(scalar\)](#): Floating-point Square Root (scalar).

[FSQRT \(vector\)](#): Floating-point Square Root (vector).

[FSUB \(scalar\)](#): Floating-point Subtract (scalar).

[FSUB \(vector\)](#): Floating-point Subtract (vector).

[INS \(element\)](#): Insert vector element from another vector element.

[INS \(general\)](#): Insert vector element from general-purpose register.

[LD1 \(multiple structures\)](#): Load multiple single-element structures to one, two, three, or four registers.

[LD1 \(single structure\)](#): Load one single-element structure to one lane of one register.

[LD1R](#): Load one single-element structure and Replicate to all lanes (of one register).

[LD2 \(multiple structures\)](#): Load multiple 2-element structures to two registers.

[LD2 \(single structure\)](#): Load single 2-element structure to one lane of two registers.

[LD2R](#): Load single 2-element structure and Replicate to all lanes of two registers.

[LD3 \(multiple structures\)](#): Load multiple 3-element structures to three registers.

[LD3 \(single structure\)](#): Load single 3-element structure to one lane of three registers.

[LD3R](#): Load single 3-element structure and Replicate to all lanes of three registers.

[LD4 \(multiple structures\)](#): Load multiple 4-element structures to four registers.

[LD4 \(single structure\)](#): Load single 4-element structure to one lane of four registers.

[LD4R](#): Load single 4-element structure and Replicate to all lanes of four registers.

[LDNP \(SIMD&FP\)](#): Load Pair of SIMD&FP registers, with Non-temporal hint.

[LDP \(SIMD&FP\)](#): Load Pair of SIMD&FP registers.

[LDR \(immediate, SIMD&FP\)](#): Load SIMD&FP Register (immediate offset).

[LDR \(literal, SIMD&FP\)](#): Load SIMD&FP Register (PC-relative literal).

[LDR \(register, SIMD&FP\)](#): Load SIMD&FP Register (register offset).

[LDUR \(SIMD&FP\)](#): Load SIMD&FP Register (unscaled offset).

[MLA \(by element\)](#): Multiply-Add to accumulator (vector, by element).

[MLA \(vector\)](#): Multiply-Add to accumulator (vector).

[MLS \(by element\)](#): Multiply-Subtract from accumulator (vector, by element).

[MLS \(vector\)](#): Multiply-Subtract from accumulator (vector).

[MOV \(element\)](#): Move vector element to another vector element: an alias of INS (element).

[MOV \(from general\)](#): Move general-purpose register to a vector element: an alias of INS (general).

[MOV \(scalar\)](#): Move vector element to scalar: an alias of DUP (element).

[MOV \(to general\)](#): Move vector element to general-purpose register: an alias of UMOV.

[MOV \(vector\)](#): Move vector: an alias of ORR (vector, register).

[MOVI](#): Move Immediate (vector).

[MUL \(by element\)](#): Multiply (vector, by element).

[MUL \(vector\)](#): Multiply (vector).

[MVN](#): Bitwise NOT (vector): an alias of NOT.

[MVNI](#): Move inverted Immediate (vector).

[NEG \(vector\)](#): Negate (vector).

[NOT](#): Bitwise NOT (vector).

[ORN \(vector\)](#): Bitwise inclusive OR NOT (vector).

[ORR \(vector, immediate\)](#): Bitwise inclusive OR (vector, immediate).

[ORR \(vector, register\)](#): Bitwise inclusive OR (vector, register).

[PMUL](#): Polynomial Multiply.

[PMULL, PMULL2](#): Polynomial Multiply Long.

[RADDHN, RADDHN2](#): Rounding Add returning High Narrow.

[RAX1](#): Rotate and Exclusive OR.

[RBIT \(vector\)](#): Reverse Bit order (vector).

[REV16 \(vector\)](#): Reverse elements in 16-bit halfwords (vector).

[REV32 \(vector\)](#): Reverse elements in 32-bit words (vector).

[REV64](#): Reverse elements in 64-bit doublewords (vector).

[RSHRN, RSHRN2](#): Rounding Shift Right Narrow (immediate).

[RSUBHN, RSUBHN2](#): Rounding Subtract returning High Narrow.

[SABA](#): Signed Absolute difference and Accumulate.

[SABAL, SABAL2](#): Signed Absolute difference and Accumulate Long.

[SABD](#): Signed Absolute Difference.

[SABDL, SABDL2](#): Signed Absolute Difference Long.

[SADALP](#): Signed Add and Accumulate Long Pairwise.

[SADDL, SADDL2](#): Signed Add Long (vector).

[SADDLP](#): Signed Add Long Pairwise.

[SADDLV](#): Signed Add Long across Vector.

[SADDW, SADDW2](#): Signed Add Wide.

[SCVTF \(scalar, fixed-point\)](#): Signed fixed-point Convert to Floating-point (scalar).

[SCVTF \(scalar, integer\)](#): Signed integer Convert to Floating-point (scalar).

[SCVTF \(vector, fixed-point\)](#): Signed fixed-point Convert to Floating-point (vector).

[SCVTF \(vector, integer\)](#): Signed integer Convert to Floating-point (vector).

[SDOT \(by element\)](#): Dot Product signed arithmetic (vector, by element).

[SDOT \(vector\)](#): Dot Product signed arithmetic (vector).

[SHA1C](#): SHA1 hash update (choose).

[SHA1H](#): SHA1 fixed rotate.

[SHA1M](#): SHA1 hash update (majority).

[SHA1P](#): SHA1 hash update (parity).

[SHA1SU0](#): SHA1 schedule update 0.

[SHA1SU1](#): SHA1 schedule update 1.

[SHA256H](#): SHA256 hash update (part 1).

[SHA256H2](#): SHA256 hash update (part 2).

[SHA256SU0](#): SHA256 schedule update 0.

[SHA256SU1](#): SHA256 schedule update 1.

[SHA512H](#): SHA512 Hash update part 1.

[SHA512H2](#): SHA512 Hash update part 2.

[SHA512SU0](#): SHA512 Schedule Update 0.

[SHA512SU1](#): SHA512 Schedule Update 1.

[SHADD](#): Signed Halving Add.

[SHL](#): Shift Left (immediate).

[SHLL](#), [SHLL2](#): Shift Left Long (by element size).

[SHRN](#), [SHRN2](#): Shift Right Narrow (immediate).

[SHSUB](#): Signed Halving Subtract.

[SLI](#): Shift Left and Insert (immediate).

[SM3PARTW1](#): SM3PARTW1.

[SM3PARTW2](#): SM3PARTW2.

[SM3SS1](#): SM3SS1.

[SM3TT1A](#): SM3TT1A.

[SM3TT1B](#): SM3TT1B.

[SM3TT2A](#): SM3TT2A.

[SM3TT2B](#): SM3TT2B.

[SM4E](#): SM4 Encode.

[SM4EKEY](#): SM4 Key.

[SMAX](#): Signed Maximum (vector).

[SMAXP](#): Signed Maximum Pairwise.

[SMAXV](#): Signed Maximum across Vector.

[SMIN](#): Signed Minimum (vector).

[SMINP](#): Signed Minimum Pairwise.

[SMINV](#): Signed Minimum across Vector.

[SMLAL](#), [SMLAL2 \(by element\)](#): Signed Multiply-Add Long (vector, by element).

[SMLAL](#), [SMLAL2 \(vector\)](#): Signed Multiply-Add Long (vector).

[SMLSL](#), [SMLSL2 \(by element\)](#): Signed Multiply-Subtract Long (vector, by element).

[SMLSL](#), [SMLSL2 \(vector\)](#): Signed Multiply-Subtract Long (vector).

[SMMLA \(vector\)](#): Signed 8-bit integer matrix multiply-accumulate (vector).

[SMOV](#): Signed Move vector element to general-purpose register.

[SMULL](#), [SMULL2 \(by element\)](#): Signed Multiply Long (vector, by element).

[SMULL](#), [SMULL2 \(vector\)](#): Signed Multiply Long (vector).

[SQABS](#): Signed saturating Absolute value.

[SQADD](#): Signed saturating Add.

[SQDMLAL](#), [SQDMLAL2 \(by element\)](#): Signed saturating Doubling Multiply-Add Long (by element).

[SQDMLAL](#), [SQDMLAL2 \(vector\)](#): Signed saturating Doubling Multiply-Add Long.

[SQDMLSL](#), [SQDMLSL2 \(by element\)](#): Signed saturating Doubling Multiply-Subtract Long (by element).

[SQDMLSL, SQDMLSL2 \(vector\)](#): Signed saturating Doubling Multiply-Subtract Long.

[SQDMULH \(by element\)](#): Signed saturating Doubling Multiply returning High half (by element).

[SQDMULH \(vector\)](#): Signed saturating Doubling Multiply returning High half.

[SQDMULL, SQDMULL2 \(by element\)](#): Signed saturating Doubling Multiply Long (by element).

[SQDMULL, SQDMULL2 \(vector\)](#): Signed saturating Doubling Multiply Long.

[SQNEG](#): Signed saturating Negate.

[SQRDMLAH \(by element\)](#): Signed Saturating Rounding Doubling Multiply Accumulate returning High Half (by element).

[SQRDMLAH \(vector\)](#): Signed Saturating Rounding Doubling Multiply Accumulate returning High Half (vector).

[SQRDMLSH \(by element\)](#): Signed Saturating Rounding Doubling Multiply Subtract returning High Half (by element).

[SQRDMLSH \(vector\)](#): Signed Saturating Rounding Doubling Multiply Subtract returning High Half (vector).

[SQRDMULH \(by element\)](#): Signed saturating Rounding Doubling Multiply returning High half (by element).

[SQRDMULH \(vector\)](#): Signed saturating Rounding Doubling Multiply returning High half.

[SQRSHL](#): Signed saturating Rounding Shift Left (register).

[SQRSHRN, SQRSHRN2](#): Signed saturating Rounded Shift Right Narrow (immediate).

[SQRSHRUN, SQRSHRUN2](#): Signed saturating Rounded Shift Right Unsigned Narrow (immediate).

[SQSHL \(immediate\)](#): Signed saturating Shift Left (immediate).

[SQSHL \(register\)](#): Signed saturating Shift Left (register).

[SQSHLU](#): Signed saturating Shift Left Unsigned (immediate).

[SQSHRN, SQSHRN2](#): Signed saturating Shift Right Narrow (immediate).

[SQSHRUN, SQSHRUN2](#): Signed saturating Shift Right Unsigned Narrow (immediate).

[SQSUB](#): Signed saturating Subtract.

[SQXTN, SQXTN2](#): Signed saturating extract Narrow.

[SQXTUN, SQXTUN2](#): Signed saturating extract Unsigned Narrow.

[SRHADD](#): Signed Rounding Halving Add.

[SRI](#): Shift Right and Insert (immediate).

[SRSHL](#): Signed Rounding Shift Left (register).

[SRSHR](#): Signed Rounding Shift Right (immediate).

[SRSRA](#): Signed Rounding Shift Right and Accumulate (immediate).

[SSHL](#): Signed Shift Left (register).

[SSHLL, SSHLL2](#): Signed Shift Left Long (immediate).

[SSHR](#): Signed Shift Right (immediate).

[SSRA](#): Signed Shift Right and Accumulate (immediate).

[SSUBL, SSUBL2](#): Signed Subtract Long.

[SSUBW, SSUBW2](#): Signed Subtract Wide.

[ST1 \(multiple structures\)](#): Store multiple single-element structures from one, two, three, or four registers.

[ST1 \(single structure\)](#): Store a single-element structure from one lane of one register.



[ST2 \(multiple structures\)](#): Store multiple 2-element structures from two registers.

[ST2 \(single structure\)](#): Store single 2-element structure from one lane of two registers.

[ST3 \(multiple structures\)](#): Store multiple 3-element structures from three registers.

[ST3 \(single structure\)](#): Store single 3-element structure from one lane of three registers.

[ST4 \(multiple structures\)](#): Store multiple 4-element structures from four registers.

[ST4 \(single structure\)](#): Store single 4-element structure from one lane of four registers.

[STNP \(SIMD&FP\)](#): Store Pair of SIMD&FP registers, with Non-temporal hint.

[STP \(SIMD&FP\)](#): Store Pair of SIMD&FP registers.

[STR \(immediate, SIMD&FP\)](#): Store SIMD&FP register (immediate offset).

[STR \(register, SIMD&FP\)](#): Store SIMD&FP register (register offset).

[STUR \(SIMD&FP\)](#): Store SIMD&FP register (unscaled offset).

[SUB \(vector\)](#): Subtract (vector).

[SUBHN, SUBHN2](#): Subtract returning High Narrow.

[SUDOT \(by element\)](#): Dot product with signed and unsigned integers (vector, by element).

[SUQADD](#): Signed saturating Accumulate of Unsigned value.

[SXTL, SXTL2](#): Signed extend Long: an alias of SSHLL, SSHLL2.

[TBL](#): Table vector Lookup.

[TBX](#): Table vector lookup extension.

[TRN1](#): Transpose vectors (primary).

[TRN2](#): Transpose vectors (secondary).

[UABA](#): Unsigned Absolute difference and Accumulate.

[UABAL, UABAL2](#): Unsigned Absolute difference and Accumulate Long.

[UABD](#): Unsigned Absolute Difference (vector).

[UABDL, UABDL2](#): Unsigned Absolute Difference Long.

[UADALP](#): Unsigned Add and Accumulate Long Pairwise.

[UADDL, UADDL2](#): Unsigned Add Long (vector).

[UADDLP](#): Unsigned Add Long Pairwise.

[UADDLV](#): Unsigned sum Long across Vector.

[UADDW, UADDW2](#): Unsigned Add Wide.

[UCVTF \(scalar, fixed-point\)](#): Unsigned fixed-point Convert to Floating-point (scalar).

[UCVTF \(scalar, integer\)](#): Unsigned integer Convert to Floating-point (scalar).

[UCVTF \(vector, fixed-point\)](#): Unsigned fixed-point Convert to Floating-point (vector).

[UCVTF \(vector, integer\)](#): Unsigned integer Convert to Floating-point (vector).

[UDOT \(by element\)](#): Dot Product unsigned arithmetic (vector, by element).

[UDOT \(vector\)](#): Dot Product unsigned arithmetic (vector).

[UHADD](#): Unsigned Halving Add.

[UHSUB](#): Unsigned Halving Subtract.

[UMAX](#): Unsigned Maximum (vector).

[UMAXP](#): Unsigned Maximum Pairwise.

[UMAXV](#): Unsigned Maximum across Vector.

[UMIN](#): Unsigned Minimum (vector).

[UMINP](#): Unsigned Minimum Pairwise.

[UMINV](#): Unsigned Minimum across Vector.

[UMLAL](#), [UMLAL2 \(by element\)](#): Unsigned Multiply-Add Long (vector, by element).

[UMLAL](#), [UMLAL2 \(vector\)](#): Unsigned Multiply-Add Long (vector).

[UMLSL](#), [UMLSL2 \(by element\)](#): Unsigned Multiply-Subtract Long (vector, by element).

[UMLSL](#), [UMLSL2 \(vector\)](#): Unsigned Multiply-Subtract Long (vector).

[UMMLA \(vector\)](#): Unsigned 8-bit integer matrix multiply-accumulate (vector).

[UMOV](#): Unsigned Move vector element to general-purpose register.

[UMULL](#), [UMULL2 \(by element\)](#): Unsigned Multiply Long (vector, by element).

[UMULL](#), [UMULL2 \(vector\)](#): Unsigned Multiply long (vector).

[UQADD](#): Unsigned saturating Add.

[UQRSHL](#): Unsigned saturating Rounding Shift Left (register).

[UQRSHRN](#), [UQRSHRN2](#): Unsigned saturating Rounded Shift Right Narrow (immediate).

[UQSHL \(immediate\)](#): Unsigned saturating Shift Left (immediate).

[UQSHL \(register\)](#): Unsigned saturating Shift Left (register).

[UQSHRN](#), [UQSHRN2](#): Unsigned saturating Shift Right Narrow (immediate).

[UQSUB](#): Unsigned saturating Subtract.

[UQXTN](#), [UQXTN2](#): Unsigned saturating extract Narrow.

[URECPE](#): Unsigned Reciprocal Estimate.

[URHADD](#): Unsigned Rounding Halving Add.

[URSHL](#): Unsigned Rounding Shift Left (register).

[URSHR](#): Unsigned Rounding Shift Right (immediate).

[URSQRTE](#): Unsigned Reciprocal Square Root Estimate.

[URSRA](#): Unsigned Rounding Shift Right and Accumulate (immediate).

[USDOT \(by element\)](#): Dot Product with unsigned and signed integers (vector, by element).

[USDOT \(vector\)](#): Dot Product with unsigned and signed integers (vector).

[USHL](#): Unsigned Shift Left (register).

[USHLL](#), [USHLL2](#): Unsigned Shift Left Long (immediate).

[USHR](#): Unsigned Shift Right (immediate).

[USMMLA \(vector\)](#): Unsigned and signed 8-bit integer matrix multiply-accumulate (vector).

[USQADD](#): Unsigned saturating Accumulate of Signed value.

[USRA](#): Unsigned Shift Right and Accumulate (immediate).

[USUBL](#), [USUBL2](#): Unsigned Subtract Long.

[USUBW](#), [USUBW2](#): Unsigned Subtract Wide.

[UXTL](#), [UXTL2](#): Unsigned extend Long: an alias of USHLL, USHLL2.

[UZP1](#): Unzip vectors (primary).

[UZP2](#): Unzip vectors (secondary).

[XAR](#): Exclusive OR and Rotate.

[XTN](#), [XTN2](#): Extract Narrow.

[ZIP1](#): Zip vectors (primary).

[ZIP2](#): Zip vectors (secondary).

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

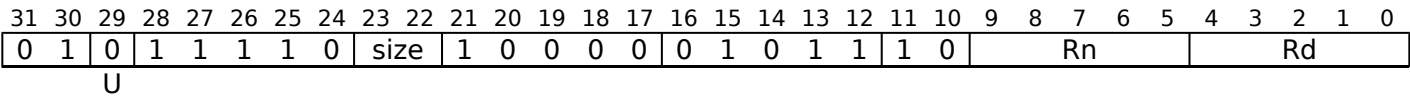
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

ABS

Absolute value (vector). This instruction calculates the absolute value of each vector element in the source SIMD&FP register, puts the result into a vector, and writes the vector to the destination SIMD&FP register.  
Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

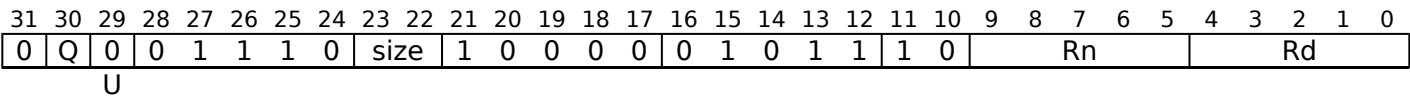


ABS <V><d>, <V><n>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean neg = (U == '1');
```

Vector



ABS <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean neg = (U == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
integer element;

for e = 0 to elements-1
    element = SInt(Elem[operand, e, esize]);
    if neg then
        element = -element;
    else
        element = Abs(element);
    Elem[result, e, esize] = element<esize-1:0>;

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

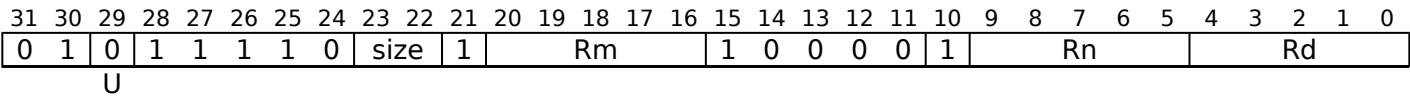
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

ADD (vector)

Add (vector). This instruction adds corresponding elements in the two source SIMD&FP registers, places the results into a vector, and writes the vector to the destination SIMD&FP register.  
Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

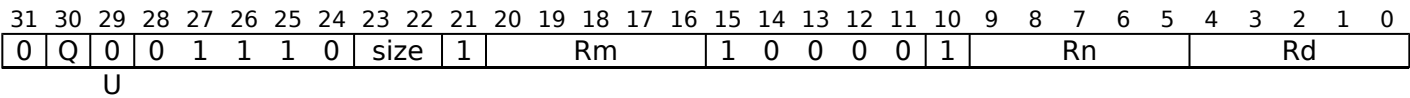
Scalar



ADD <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean sub_op = (U == '1');
```

Vector



ADD <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean sub_op = (U == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    if sub_op then
        Elem[result, e, esize] = element1 - element2;
    else
        Elem[result, e, esize] = element1 + element2;

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

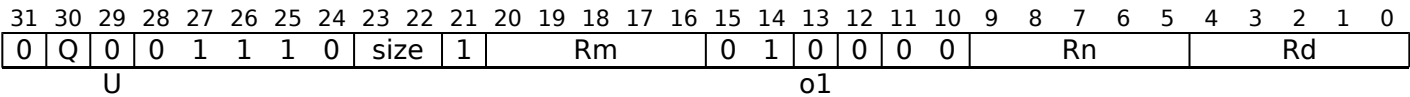
- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

ADDHN, ADDHN2

Add returning High Narrow. This instruction adds each vector element in the first source SIMD&FP register to the corresponding vector element in the second source SIMD&FP register, places the most significant half of the result into a vector, and writes the vector to the lower or upper half of the destination SIMD&FP register. The results are truncated. For rounded results, see [RADDHN](#). The ADDHN instruction writes the vector to the lower half of the destination register and clears the upper half, while the ADDHN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register. Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



ADDHN{2} <Vd>.<Tb>, <Vn>.<Ta>, <Vm>.<Ta>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean sub_op = (o1 == '1');
boolean round = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED



<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(2*datasize) operand1 = V[n];
bits(2*datasize) operand2 = V[m];
bits(datasize) result;
integer round_const = if round then 1 << (esize - 1) else 0;
bits(2*esize) element1;
bits(2*esize) element2;
bits(2*esize) sum;

for e = 0 to elements-1
    element1 = Elem[operand1, e, 2*esize];
    element2 = Elem[operand2, e, 2*esize];
    if sub_op then
        sum = element1 - element2;
    else
        sum = element1 + element2;
    sum = sum + round_const;
    Elem[result, e, esize] = sum<2*esize-1:esize>;

Vpart[d, part] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

ADDP (scalar)

Add Pair of elements (scalar). This instruction adds two vector elements in the source SIMD&FP register and writes the scalar result into the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	size		1	1	0	0	0	1	1	0	1	1	1	0	Rn				Rd					

ADDP <V><d>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size != '11' then UNDEFINED;

integer esize = 8 << UInt(size);
integer datasize = esize * 2;
```

Assembler Symbols

<V> Is the destination width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<T> Is the source arrangement specifier, encoded in “size”:

size	<T>
0x	RESERVED
10	RESERVED
11	2D

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
V[d] = Reduce(ReduceOp_ADD, operand, esize);
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

ADDP (vector)

Add Pairwise (vector). This instruction creates a vector by concatenating the vector elements of the first source SIMD&FP register after the vector elements of the second source SIMD&FP register, reads each pair of adjacent vector elements from the concatenated vector, adds each pair of values together, places the result into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	size	1	Rm						1	0	1	1	1	1	Rn						Rd			

ADDP <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(2*datasize) concat = operand2:operand1;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    element1 = Elem[concat, 2*e, esize];
    element2 = Elem[concat, (2*e)+1, esize];
    Elem[result, e, esize] = element1 + element2;

V[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:

- The values of the data supplied in any of its registers.
- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

ADDV

Add across Vector. This instruction adds every vector element in the source SIMD&FP register together, and writes the scalar result to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	size	1	1	0	0	0	1	1	0	1	1	1	0		Rn					Rd				

ADDV <V><d>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '100' then UNDEFINED;
if size == '11' then UNDEFINED;

integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
```

Assembler Symbols

<V> Is the destination width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<T> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	RESERVED
10	1	4S
11	x	RESERVED

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
V[d] = Reduce(ReduceOp_ADD, operand, esize);
```

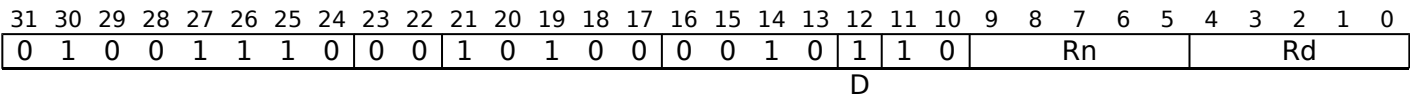
Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.



AESD

AES single round decryption.



AESD <Vd>.16B, <Vn>.16B

```
integer d = UInt(Rd);
integer n = UInt(Rn);
if !HaveAESExt() then UNDEFINED;
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the second SIMD&FP source register, encoded in the "Rn" field.

Operation

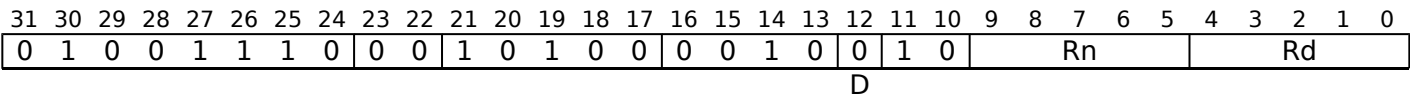
```
AArch64.CheckFPAdvSIMDEnabled();
bits(128) operand1 = V[d];
bits(128) operand2 = V[n];
bits(128) result;
result = operand1 EOR operand2;
result = AESInvSubBytes(AESInvShiftRows(result));
V[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

AESE

AES single round encryption.



AESE <Vd>.16B, <Vn>.16B

```
integer d = UInt(Rd);
integer n = UInt(Rn);
if !HaveAESExt() then UNDEFINED;
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the second SIMD&FP source register, encoded in the "Rn" field.

Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) operand1 = V[d];
bits(128) operand2 = V[n];
bits(128) result;
result = operand1 EOR operand2;
result = AESSubBytes(AESShiftRows(result));

V[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.



# AESIMC

AES inverse mix columns.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	1	1	1	0	0	0	1	0	1	0	0	0	0	1	1	1	1	0	Rn				Rd					
D																															

AESIMC <Vd>.16B, <Vn>.16B

```
integer d = UInt(Rd);
integer n = UInt(Rn);
if !HaveAEEExt() then UNDEFINED;
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();
bits(128) operand = V[n];
bits(128) result;
result = AESInvMixColumns(operand);
V[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# AESMC

AES mix columns.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	1	1	1	0	0	0	1	0	1	0	0	0	0	1	1	0	1	0	Rn				Rd					
D																															

AESMC <Vd>.16B, <Vn>.16B

```
integer d = UInt(Rd);
integer n = UInt(Rn);
if !HaveAEEExt() then UNDEFINED;
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();
bits(128) operand = V[n];
bits(128) result;
result = AESMixColumns(operand);
V[d] = result;
```

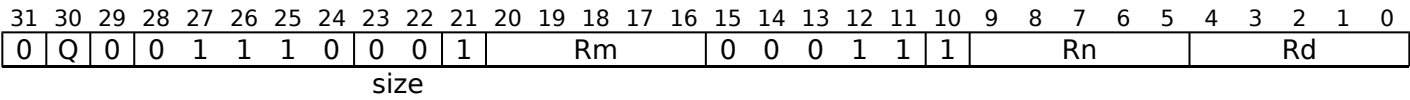
## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# AND (vector)

Bitwise AND (vector). This instruction performs a bitwise AND between the two source SIMD&FP registers, and writes the result to the destination SIMD&FP register.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



```
AND <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if Q == '1' then 128 else 64;
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "Q":
- | Q | <T> |
|---|-----|
| 0 | 8B  |
| 1 | 16B |
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

result = operand1 AND operand2;
V[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# BCAX

Bit Clear and Exclusive OR performs a bitwise AND of the 128-bit vector in a source SIMD&FP register and the complement of the vector in another source SIMD&FP register, then performs a bitwise exclusive OR of the resulting vector and the vector in a third source SIMD&FP register, and writes the result to the destination SIMD&FP register. This instruction is implemented only when *FEAT\_SHA3* is implemented.

## Advanced SIMD (FEAT\_SHA3)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	0	1					Rm	0															Rd

BCAX <Vd>.16B, <Vn>.16B, <Vm>.16B, <Va>.16B

```
if !HaveSHA3Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer a = UInt(Ra);
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Va> Is the name of the third SIMD&FP source register, encoded in the "Ra" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) Vm = V[m];
bits(128) Vn = V[n];
bits(128) Va = V[a];
V[d] = Vn EOR (Vm AND NOT(Va));
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

BFCVT

Floating-point convert from single-precision to BFloat16 format (scalar) converts the single-precision floating-point value in the 32-bit SIMD&FP source register to BFloat16 format and writes the result in the 16-bit SIMD&FP destination register.

Unlike the BFloat16 multiplication instructions, this instruction honors all the control bits in the *FPCR* that apply to single-precision arithmetic, including the rounding mode. This instruction can generate a floating-point exception that causes a cumulative exception bit in the *FPSR* to be set, or a synchronous exception to be taken, depending on the enable bits in the *FPCR*. *ID\_AA64ISAR1\_EL1*.BF16 indicates whether this instruction is supported.

Single-precision to BFloat16  
(FEAT\_BF16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1	1	1	1	0	0	1	1	0	0	0	1	1	0	1	0	0	0	0	Rn				Rd					

BFCVT <Hd>, <Sn>

```
if !HaveBF16Ext() then UNDEFINED;
integer n = UInt(Rn);
integer d = UInt(Rd);
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();

bits(32) operand = V[n];
FPCRType fpcr = FPCR[];
boolean merge = IsMerging(fpcr);
bits(128) result = if merge then V[d] else Zeros();

Elem[result, 0, 16] = FPConvertBF(operand, fpcr);

V[d] = result;
```

BFCVTN, BFCVTN2

Floating-point convert from single-precision to BFloat16 format (vector) reads each single-precision element in the SIMD&FP source vector, converts each value to BFloat16 format, and writes the results in the lower or upper half of the SIMD&FP destination vector. The result elements are half the width of the source elements.

The BFCVTN instruction writes the half-width results to the lower half of the destination vector and clears the upper half to zero, while the BFCVTN2 instruction writes the results to the upper half of the destination vector without affecting the other bits in the register.

Unlike the BFloat16 multiplication instructions, this instruction honors all of the control bits in the *FPCR* that apply to single-precision arithmetic, including the rounding mode. It can also generate a floating-point exception that causes cumulative exception bits in the *FPSR* to be set, or a synchronous exception to be taken, depending on the enable bits in the *FPCR*.

Vector single-precision to BFloat16  
(FEAT\_BF16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	0	1	0	0	0	0	1	0	1	1	0	1	0	Rn				Rd					

BFCVTN{2} <Vd>.<Ta>, <Vn>.4S

```
if !HaveBF16Ext() then UNDEFINED;
integer n = UInt(Rn);
integer d = UInt(Rd);
integer part = UInt(Q);
integer elements = 64 DIV 16;
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q 2	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “Q”:

Q <Ta>	
0	4H
1	8H

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(128) operand = V[n];
bits(64) result;

for e = 0 to elements-1
    Elem[result, e, 16] = FPCConvertBF(Elem[operand, e, 32], FPCR[]);
Vpart[d, part] = result;
```

BFDOT (by element)

BFloat16 floating-point dot product (vector, by element). This instruction delimits the source vectors into pairs of 16-bit BF16 elements. Each pair of elements in the first source vector is multiplied by the specified pair of elements in the second source vector. The resulting single-precision products are then summed and added destructively to the single-precision element of the destination vector that aligns with the pair of BF16 values in the first source vector. The instruction ignores the *FPCR* and does not update the *FPSR* exception status.

The BF16 pair within the second source vector is specified using an immediate index. The index range is from 0 to 3 inclusive. *ID\_AA64ISAR1\_EL1*.BF16 indicates whether this instruction is supported.

Vector  
(FEAT\_BF16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	0	1	L	M	Rm				1	1	1	1	H	0	Rn				Rd					

BFDOT <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.2H[<index>]

```
if !HaveBF16Ext() then UNDEFINED;
integer n = UInt(Rn);
integer m = UInt(M:Rm);
integer d = UInt(Rd);
integer i = UInt(H:L);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV 32;
```

Assembler Symbols

- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Ta>

Is an arrangement specifier, encoded in "Q":

Q	<Ta>
0	2S
1	4S
- <Vn>

Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Tb>

Is an arrangement specifier, encoded in "Q":

Q	<Tb>
0	4H
1	8H
- <Vm>

Is the name of the second SIMD&FP source register, encoded in the "M:Rm" fields.
- <index>

Is the immediate index of a pair of 16-bit elements in the range 0 to 3, encoded in the "H:L" fields.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(128) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;

for e = 0 to elements-1
    bits(16) elt1_a = Elem[operand1, 2*e+0, 16];
    bits(16) elt1_b = Elem[operand1, 2*e+1, 16];
    bits(16) elt2_a = Elem[operand2, 2*i+0, 16];
    bits(16) elt2_b = Elem[operand2, 2*i+1, 16];

    bits(32) sum = Elem[operand3, e, 32];
    sum = BFDotAdd(sum, elt1_a, elt1_b, elt2_a, elt2_b, FPCR[]);
    Elem[result, e, 32] = sum;

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# BFDOT (vector)

BFloat16 floating-point dot product (vector). This instruction delimits the source vectors into pairs of 16-bit BF16 elements. Within each pair, the elements in the first source vector are multiplied by the corresponding elements in the second source vector. The resulting single-precision products are then summed and added destructively to the single-precision element of the destination vector that aligns with the pair of BF16 values in the first source vector. The instruction ignores the *FPCR* and does not update the *FPSR* exception status.

## Vector (FEAT\_BF16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	1	0	Rm				1	1	1	1	1	1	Rn				Rd						

**BFDOT** <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
if !HaveBF16Ext() then UNDEFINED;
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Rd);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV 32;
```

## Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in "Q":

Q	<Ta>
0	2S
1	4S

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in "Q":

Q	<Tb>
0	4H
1	8H

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;

for e = 0 to elements-1
    bits(16) elt1_a = Elem[operand1, 2*e+0, 16];
    bits(16) elt1_b = Elem[operand1, 2*e+1, 16];
    bits(16) elt2_a = Elem[operand2, 2*e+0, 16];
    bits(16) elt2_b = Elem[operand2, 2*e+1, 16];

    bits(32) sum = Elem[operand3, e, 32];
    sum = BFDotAdd(sum, elt1_a, elt1_b, elt2_a, elt2_b, FPCR[]);
    Elem[result, e, 32] = sum;

V[d] = result;
```



BFMLALB, BFMLALT (by element)

BFloat16 floating-point widening multiply-add long (by element) widens the even-numbered (bottom) or odd-numbered (top) 16-bit elements in the first source vector, and the indexed element in the second source vector from Bfloat16 to single-precision format. The instruction then multiplies and adds these values to the overlapping single-precision elements of the destination vector.

This performs a fused multiply-add without intermediate rounding that honors all of the control bits in the *FPCR* that apply to single-precision arithmetic, including the rounding mode. It can also generate a floating-point exception that causes cumulative exception bits in the *FPSR* to be set, or a synchronous exception to be taken, depending on the enable bits in the *FPCR*. *ID\_AA64ISAR1\_EL1*.BF16 indicates whether this instruction is supported.

Vector  
(FEAT\_BF16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	1	1	L	M	Rm				1	1	1	1	H	0	Rn				Rd					

BFMLAL<bt> <Vd>.4S, <Vn>.8H, <Vm>.H[<index>]

```
if !HaveBF16Ext() then UNDEFINED;
integer n = UInt(Rn);
integer m = UInt('0':Rm);
integer d = UInt(Rd);
integer index = UInt(H:L:M);

integer elements = 128 DIV 32;
integer sel = UInt(Q);
```

Assembler Symbols

- <bt> Is the bottom or top element specifier, encoded in "Q":
- | Q | <bt> |
|---|------|
| 0 | B    |
| 1 | T    |
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, in the range V0 to V15, encoded in the "Rm" field.
- <index> Is the element index, in the range 0 to 7, encoded in the "H:L:M" fields.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(128) result;
bits(128) operand1 = V[n];
bits(128) operand2 = V[m];
bits(128) operand3 = V[d];
bits(32) element2 = Elem[operand2, index, 16]:Zeros(16);

for e = 0 to elements-1
  bits(32) element1 = Elem[operand1, 2*e+sel, 16]:Zeros(16);
  bits(32) addend = Elem[operand3, e, 32];
  Elem[result, e, 32] = BFMulAdd(addend, element1, element2, FPCR[]);

V[d] = result;
```

BFMLALB, BFMLALT (vector)

BFloat16 floating-point widening multiply-add long (vector) widens the even-numbered (bottom) or odd-numbered (top) 16-bit elements in the first and second source vectors from Bfloat16 to single-precision format. The instruction then multiplies and adds these values to the overlapping single-precision elements of the destination vector. This performs a fused multiply-add without intermediate rounding that honors all of the control bits in the *FPCR* that apply to single-precision arithmetic, including the rounding mode. It can also generate a floating-point exception that causes cumulative exception bits in the *FPSR* to be set, or a synchronous exception to be taken, depending on the enable bits in the *FPCR*. *ID\_AA64ISAR1\_EL1*.BF16 indicates whether these instruction is supported.

Vector  
(FEAT\_BF16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	1	0	Rm				1	1	1	1	1	1	Rn				Rd						

BFMLAL<bt> <Vd>.4S, <Vn>.8H, <Vm>.8H

```
if !HaveBF16Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer elements = 128 DIV 32;
integer sel = UInt(Q);
```

Assembler Symbols

- <bt> Is the bottom or top element specifier, encoded in “Q”:

Q	<bt>
0	B
1	T
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(128) operand1 = V[n];
bits(128) operand2 = V[m];
bits(128) operand3 = V[d];
bits(128) result;

for e = 0 to elements-1
    bits(32) element1 = Elem[operand1, 2*e+sel, 16]:Zeros(16);
    bits(32) element2 = Elem[operand2, 2*e+sel, 16]:Zeros(16);
    bits(32) addend = Elem[operand3, e, 32];
    Elem[result, e, 32] = BFMulAdd(addend, element1, element2, FPCR[]);

V[d] = result;
```

# BFMMLA

BFloat16 floating-point matrix multiply-accumulate into 2x2 matrix. This instruction multiplies the 2x4 matrix of BF16 values held in the first 128-bit source vector by the 4x2 BF16 matrix in the second 128-bit source vector. The resulting 2x2 single-precision matrix product is then added destructively to the 2x2 single-precision matrix in the 128-bit destination vector. This is equivalent to performing a 4-way dot product per destination element. The instruction ignores the *FPCR* and does not update the *FPSR* exception status.

Arm expects that the BFMMLA instruction will deliver a peak BF16 multiply throughput that is at least as high as can be achieved using two BFDOT instructions, with a goal that it should have significantly higher throughput.

## Vector (FEAT\_BF16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	1	1	0	0	1	0	Rm				1	1	1	0	1	1	Rn				Rd						

BFMMLA <Vd>.4S, <Vn>.8H, <Vm>.8H

```
if !HaveBF16Ext() then UNDEFINED;
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Rd);
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP third source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

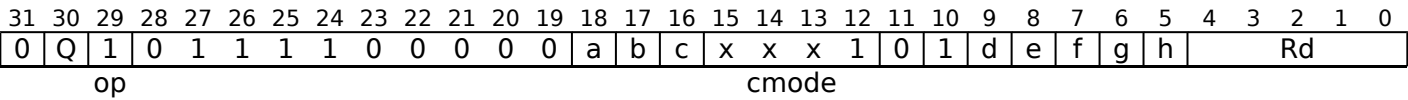
```
CheckFPAdvSIMDEnabled64();
bits(128) op1 = V[n];
bits(128) op2 = V[m];
bits(128) acc = V[d];

V[d] = BFMatMulAdd(acc, op1, op2);
```

BIC (vector, immediate)

Bitwise bit Clear (vector, immediate). This instruction reads each vector element from the destination SIMD&FP register, performs a bitwise AND between each result and the complement of an immediate constant, places the result into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



16-bit (cmode == 10x1)

```
BIC <Vd>.<T>, #<imm8>{, LSL #<amount>}
```

32-bit (cmode == 0xx1)

```
BIC <Vd>.<T>, #<imm8>{, LSL #<amount>}
```

```
integer rd = UInt(Rd);

integer datasize = if Q == '1' then 128 else 64;
bits(datasize) imm;
bits(64) imm64;

ImmediateOp operation;
case cmode:op of
  when '0xx01' operation = ImmediateOp_MVNI;
  when '0xx11' operation = ImmediateOp_BIC;
  when '10x01' operation = ImmediateOp_MVNI;
  when '10x11' operation = ImmediateOp_BIC;
  when '110x1' operation = ImmediateOp_MVNI;
  when '1110x' operation = ImmediateOp_MOVI;
  when '11111'
    // FMOV Dn,#imm is in main FP instruction set
    if Q == '0' then UNDEFINED;
    operation = ImmediateOp_MOVI;

imm64 = AdvSIMDExpandImm(op, cmode, a:b:c:d:e:f:g:h);
imm = Replicate(imm64, datasize DIV 64);
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP register, encoded in the "Rd" field.

<T> For the 16-bit variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the 32-bit variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	2S
1	4S

<imm8> Is an 8-bit immediate encoded in "a:b:c:d:e:f:g:h".

<amount> For the 16-bit variant: is the shift amount encoded in "cmode<1>":

<b>cmode&lt;1&gt;</b>	<b>&lt;amount&gt;</b>
0	0
1	8

defaulting to 0 if LSL is omitted.

For the 32-bit variant: is the shift amount encoded in “cmode<2:1>”:

<b>cmode&lt;2:1&gt;</b>	<b>&lt;amount&gt;</b>
00	0
01	8
10	16
11	24

defaulting to 0 if LSL is omitted.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand;
bits(datasize) result;

case operation of
  when ImmediateOp_MOVI
    result = imm;
  when ImmediateOp_MVNI
    result = NOT(imm);
  when ImmediateOp_ORR
    operand = V[rd];
    result = operand OR imm;
  when ImmediateOp_BIC
    operand = V[rd];
    result = operand AND NOT(imm);

V[rd] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

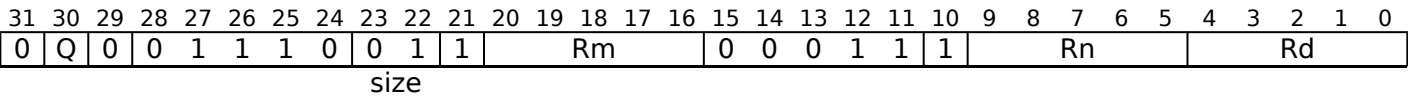
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# BIC (vector, register)

Bitwise bit Clear (vector, register). This instruction performs a bitwise AND between the first source SIMD&FP register and the complement of the second source SIMD&FP register, and writes the result to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



**BIC** <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if Q == '1' then 128 else 64;
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "Q":
- | Q | <T> |
|---|-----|
| 0 | 8B  |
| 1 | 16B |
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

operand2 = NOT(operand2);

result = operand1 AND operand2;
V[d] = result;
```

## Operational information

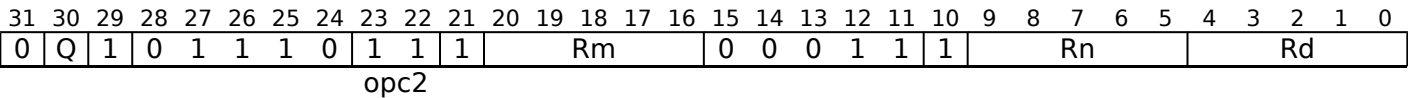
- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.



BIF

Bitwise Insert if False. This instruction inserts each bit from the first source SIMD&FP register into the destination SIMD&FP register if the corresponding bit of the second source SIMD&FP register is 0, otherwise leaves the bit in the destination register unchanged.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



BIF <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if Q == '1' then 128 else 64;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "Q":

Q	<T>
0	8B
1	16B

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1;
bits(datasize) operand3;
bits(datasize) operand4 = V[n];

operand1 = V[d];
operand3 = NOT(V[m]);

V[d] = operand1 EOR ((operand1 EOR operand4) AND operand3);
```

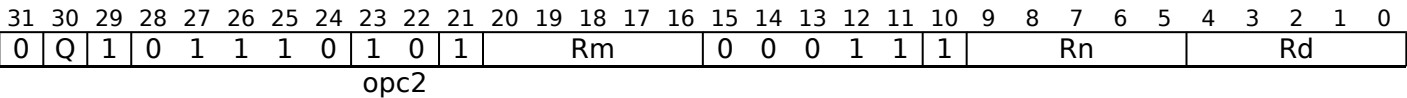
Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

BIT

Bitwise Insert if True. This instruction inserts each bit from the first source SIMD&FP register into the SIMD&FP destination register if the corresponding bit of the second source SIMD&FP register is 1, otherwise leaves the bit in the destination register unchanged.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



BIT <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if Q == '1' then 128 else 64;
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "Q":

Q	<T>
0	8B
1	16B
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1;
bits(datasize) operand3;
bits(datasize) operand4 = V[n];

operand1 = V[d];
operand3 = V[m];
V[d] = operand1 EOR ((operand1 EOR operand4) AND operand3);
```

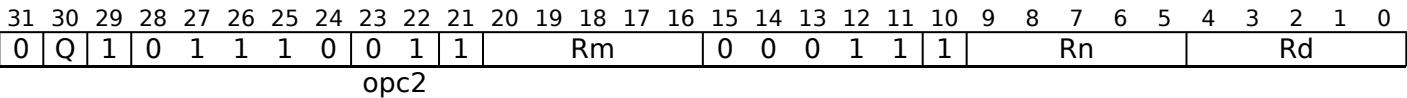
Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

BSL

Bitwise Select. This instruction sets each bit in the destination SIMD&FP register to the corresponding bit from the first source SIMD&FP register when the original destination bit was 1, otherwise from the second source SIMD&FP register.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



BSL <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if Q == '1' then 128 else 64;
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "Q":

Q	<T>
0	8B
1	16B
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1;
bits(datasize) operand3;
bits(datasize) operand4 = V[n];

operand1 = V[m];
operand3 = V[d];
V[d] = operand1 EOR ((operand1 EOR operand4) AND operand3);
```

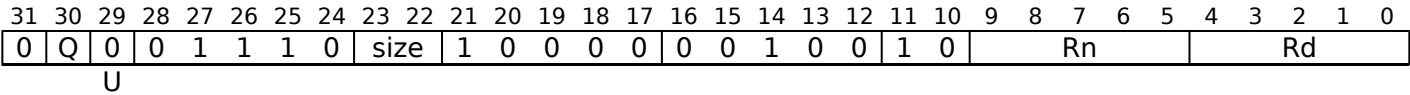
Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

CLS (vector)

Count Leading Sign bits (vector). This instruction counts the number of consecutive bits following the most significant bit that are the same as the most significant bit in each vector element in the source SIMD&FP register, places the result into a vector, and writes the vector to the destination SIMD&FP register. The count does not include the most significant bit itself.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



CLS <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CountOp countop = if U == '1' then CountOp_CLZ else CountOp_CLS;
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;

integer count;
for e = 0 to elements-1
    if countop == CountOp_CLS then
        count = CountLeadingSignBits(Elem[operand, e, esize]);
    else
        count = CountLeadingZeroBits(Elem[operand, e, esize]);
    Elem[result, e, esize] = count<esize-1:0>;
V[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

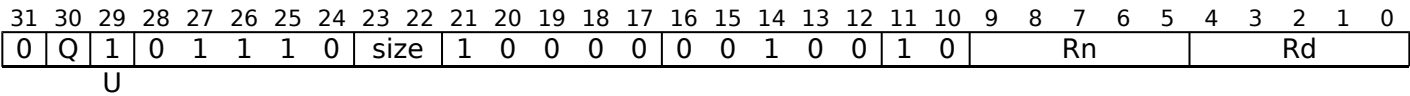
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

CLZ (vector)

Count Leading Zero bits (vector). This instruction counts the number of consecutive zeros, starting from the most significant bit, in each vector element in the source SIMD&FP register, places the result into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



CLZ <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CountOp countop = if U == '1' then CountOp_CLZ else CountOp_CLS;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;

integer count;
for e = 0 to elements-1
    if countop == CountOp_CLS then
        count = CountLeadingSignBits(Elem[operand, e, esize]);
    else
        count = CountLeadingZeroBits(Elem[operand, e, esize]);
    Elem[result, e, esize] = count<size-1:0>;
V[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:

- The values of the data supplied in any of its registers.
- The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## CMEQ (register)

Compare bitwise Equal (vector). This instruction compares each vector element from the first source SIMD&FP register with the corresponding vector element from the second source SIMD&FP register, and if the comparison is equal sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	1	1	1	1	1	1	0	size	1	Rm						1	0	0	0	1	1	Rn						Rd					
U																																	

CMEQ <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean and_test = (U == '0');
```

### Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	Q	1	0	1	1	1	0	size	1	Rm						1	0	0	0	1	1	Rn						Rd					
U																																	

CMEQ <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean and_test = (U == '0');
```

### Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.



<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;
boolean test_passed;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    if and_test then
        test_passed = !IsZero(element1 AND element2);
    else
        test_passed = (element1 == element2);
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# CMEQ (zero)

Compare bitwise Equal to zero (vector). This instruction reads each vector element in the source SIMD&FP register and if the value is equal to zero sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	size		1	0	0	0	0	0	1	0	0	1	1	0	Rn				Rd					
U										op																					

CMEQ <V><d>, <V><n>, #0

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;

CompareOp comparison;
case op:U of
  when '00' comparison = CompareOp_GT;
  when '01' comparison = CompareOp_GE;
  when '10' comparison = CompareOp_EQ;
  when '11' comparison = CompareOp_LE;
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	size		1	0	0	0	0	0	1	0	0	1	1	0	Rn				Rd					
U										op																					

CMEQ <Vd>.<T>, <Vn>.<T>, #0

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CompareOp comparison;
case op:U of
  when '00' comparison = CompareOp_GT;
  when '01' comparison = CompareOp_GE;
  when '10' comparison = CompareOp_EQ;
  when '11' comparison = CompareOp_LE;
```

## Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
integer element;
boolean test_passed;

for e = 0 to elements-1
    element = SInt(Elem[operand, e, esize]);
    case comparison of
        when CompareOp_GT test_passed = element > 0;
        when CompareOp_GE test_passed = element >= 0;
        when CompareOp_EQ test_passed = element == 0;
        when CompareOp_LE test_passed = element <= 0;
        when CompareOp_LT test_passed = element < 0;
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

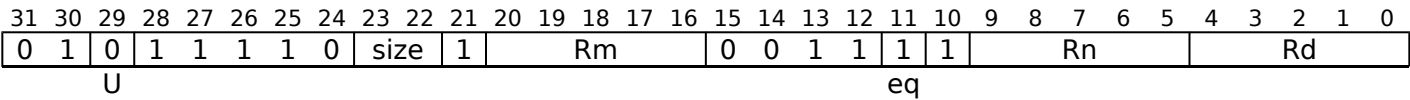
## CMGE (register)

Compare signed Greater than or Equal (vector). This instruction compares each vector element in the first source SIMD&FP register with the corresponding vector element in the second source SIMD&FP register and if the first signed integer value is greater than or equal to the second signed integer value sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

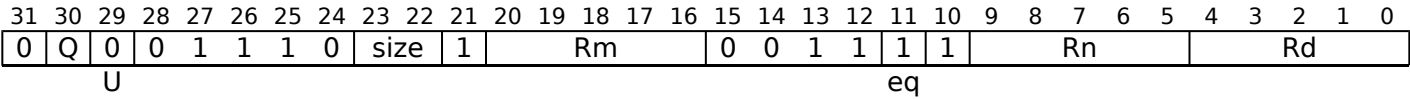
### Scalar



CMGE [<V><d>](#), [<V><n>](#), [<V><m>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
boolean cmp_eq = (eq == '1');
```

### Vector



CMGE [<Vd>.<T>](#), [<Vn>.<T>](#), [<Vm>.<T>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
boolean cmp_eq = (eq == '1');
```

### Assembler Symbols

[<V>](#) Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D

[<d>](#) Is the number of the SIMD&FP destination register, in the “Rd” field.

[<n>](#) Is the number of the first SIMD&FP source register, encoded in the “Rn” field.

[<m>](#) Is the number of the second SIMD&FP source register, encoded in the “Rm” field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
boolean test_passed;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    test_passed = if cmp_eq then element1 >= element2 else element1 > element2;
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

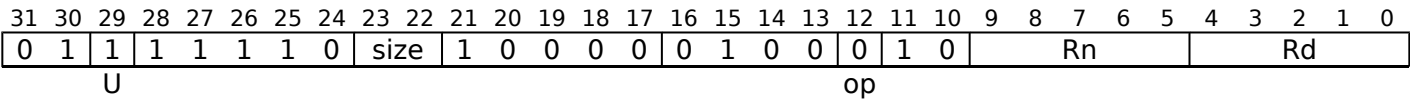
# CMGE (zero)

Compare signed Greater than or Equal to zero (vector). This instruction reads each vector element in the source SIMD&FP register and if the signed integer value is greater than or equal to zero sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar



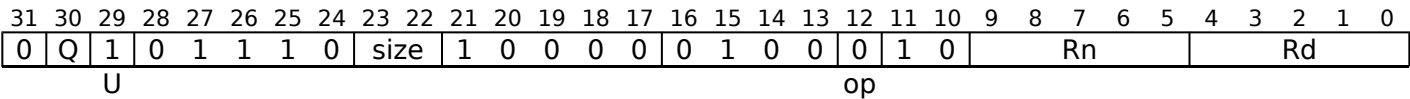
CMGE [<V><d>](#), [<V><n>](#), #0

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;

CompareOp comparison;
case op:U of
  when '00' comparison = CompareOp_GT;
  when '01' comparison = CompareOp_GE;
  when '10' comparison = CompareOp_EQ;
  when '11' comparison = CompareOp_LE;
```

## Vector



CMGE [<Vd>.<T>](#), [<Vn>.<T>](#), #0

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CompareOp comparison;
case op:U of
  when '00' comparison = CompareOp_GT;
  when '01' comparison = CompareOp_GE;
  when '10' comparison = CompareOp_EQ;
  when '11' comparison = CompareOp_LE;
```

## Assembler Symbols

[<V>](#) Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
integer element;
boolean test_passed;

for e = 0 to elements-1
    element = SInt(Elem[operand, e, esize]);
    case comparison of
        when CompareOp_GT test_passed = element > 0;
        when CompareOp_GE test_passed = element >= 0;
        when CompareOp_EQ test_passed = element == 0;
        when CompareOp_LE test_passed = element <= 0;
        when CompareOp_LT test_passed = element < 0;
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

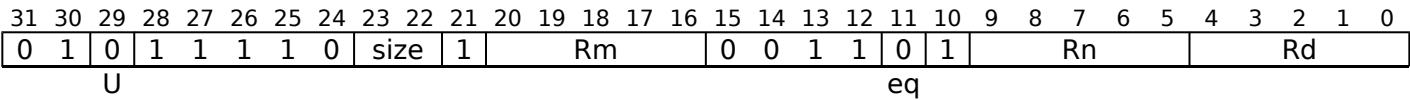
# CMGT (register)

Compare signed Greater than (vector). This instruction compares each vector element in the first source SIMD&FP register with the corresponding vector element in the second source SIMD&FP register and if the first signed integer value is greater than the second signed integer value sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

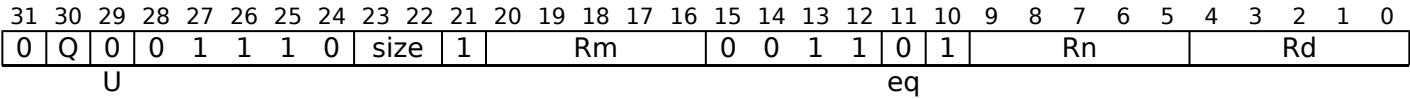
## Scalar



CMGT [<V><d>](#), [<V><n>](#), [<V><m>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
boolean cmp_eq = (eq == '1');
```

## Vector



CMGT [<Vd>.<T>](#), [<Vn>.<T>](#), [<Vm>.<T>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
boolean cmp_eq = (eq == '1');
```

## Assembler Symbols

[<V>](#) Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D

[<d>](#) Is the number of the SIMD&FP destination register, in the “Rd” field.

[<n>](#) Is the number of the first SIMD&FP source register, encoded in the “Rn” field.

[<m>](#) Is the number of the second SIMD&FP source register, encoded in the “Rm” field.



<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
boolean test_passed;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    test_passed = if cmp_eq then element1 >= element2 else element1 > element2;
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

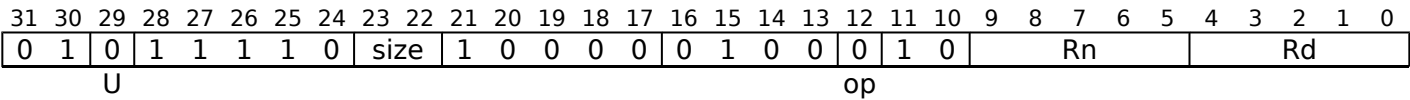
# CMGT (zero)

Compare signed Greater than zero (vector). This instruction reads each vector element in the source SIMD&FP register and if the signed integer value is greater than zero sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar



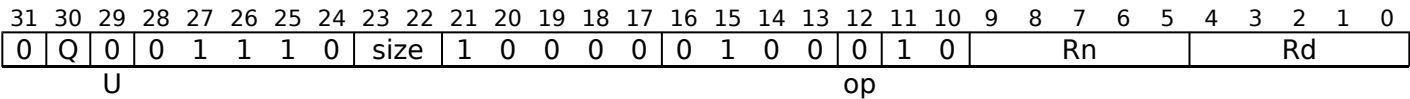
CMGT <V><d>, <V><n>, #0

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;

CompareOp comparison;
case op:U of
  when '00' comparison = CompareOp_GT;
  when '01' comparison = CompareOp_GE;
  when '10' comparison = CompareOp_EQ;
  when '11' comparison = CompareOp_LE;
```

## Vector



CMGT <Vd>.<T>, <Vn>.<T>, #0

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CompareOp comparison;
case op:U of
  when '00' comparison = CompareOp_GT;
  when '01' comparison = CompareOp_GE;
  when '10' comparison = CompareOp_EQ;
  when '11' comparison = CompareOp_LE;
```

## Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
integer element;
boolean test_passed;

for e = 0 to elements-1
    element = SInt(Elem[operand, e, esize]);
    case comparison of
        when CompareOp_GT test_passed = element > 0;
        when CompareOp_GE test_passed = element >= 0;
        when CompareOp_EQ test_passed = element == 0;
        when CompareOp_LE test_passed = element <= 0;
        when CompareOp_LT test_passed = element < 0;
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

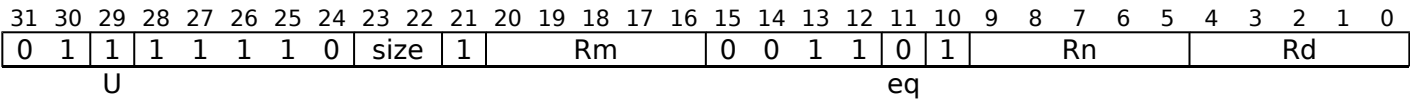
## CMHI (register)

Compare unsigned Higher (vector). This instruction compares each vector element in the first source SIMD&FP register with the corresponding vector element in the second source SIMD&FP register and if the first unsigned integer value is greater than the second unsigned integer value sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

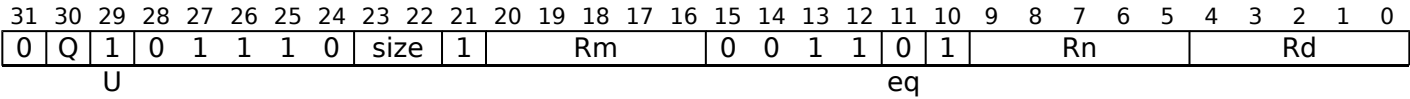
### Scalar



CMHI [<V><d>](#), [<V><n>](#), [<V><m>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
boolean cmp_eq = (eq == '1');
```

### Vector



CMHI [<Vd>.<T>](#), [<Vn>.<T>](#), [<Vm>.<T>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
boolean cmp_eq = (eq == '1');
```

### Assembler Symbols

[<V>](#) Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D

[<d>](#) Is the number of the SIMD&FP destination register, in the “Rd” field.

[<n>](#) Is the number of the first SIMD&FP source register, encoded in the “Rn” field.

[<m>](#) Is the number of the second SIMD&FP source register, encoded in the “Rm” field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
boolean test_passed;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    test_passed = if cmp_eq then element1 >= element2 else element1 > element2;
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

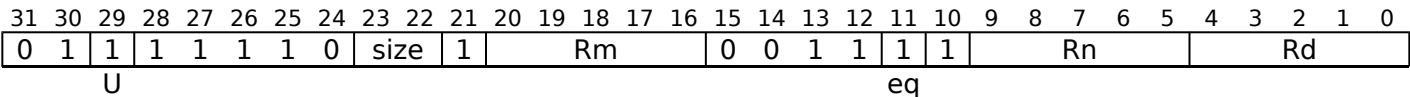
## CMHS (register)

Compare unsigned Higher or Same (vector). This instruction compares each vector element in the first source SIMD&FP register with the corresponding vector element in the second source SIMD&FP register and if the first unsigned integer value is greater than or equal to the second unsigned integer value sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

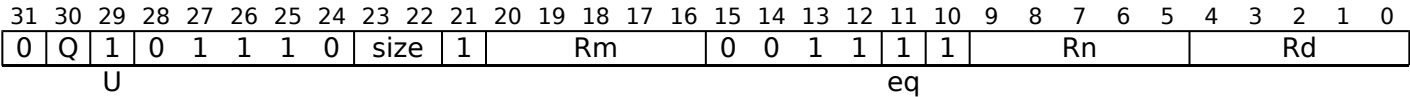
### Scalar



CMHS [<V>](#)[<d>](#), [<V>](#)[<n>](#), [<V>](#)[<m>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
boolean cmp_eq = (eq == '1');
```

### Vector



CMHS [<Vd>](#)[.<T>](#), [<Vn>](#)[.<T>](#), [<Vm>](#)[.<T>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
boolean cmp_eq = (eq == '1');
```

### Assembler Symbols

[<V>](#) Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D

[<d>](#) Is the number of the SIMD&FP destination register, in the “Rd” field.

[<n>](#) Is the number of the first SIMD&FP source register, encoded in the “Rn” field.

[<m>](#) Is the number of the second SIMD&FP source register, encoded in the “Rm” field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
boolean test_passed;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    test_passed = if cmp_eq then element1 >= element2 else element1 > element2;
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# CMLE (zero)

Compare signed Less than or Equal to zero (vector). This instruction reads each vector element in the source SIMD&FP register and if the signed integer value is less than or equal to zero sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	size		1	0	0	0	0	0	1	0	0	1	1	0	Rn				Rd					
U										op																					

CMLE <V><d>, <V><n>, #0

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;

CompareOp comparison;
case op:U of
  when '00' comparison = CompareOp_GT;
  when '01' comparison = CompareOp_GE;
  when '10' comparison = CompareOp_EQ;
  when '11' comparison = CompareOp_LE;
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	size		1	0	0	0	0	0	1	0	0	1	1	0	Rn				Rd					
U										op																					

CMLE <Vd>.<T>, <Vn>.<T>, #0

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CompareOp comparison;
case op:U of
  when '00' comparison = CompareOp_GT;
  when '01' comparison = CompareOp_GE;
  when '10' comparison = CompareOp_EQ;
  when '11' comparison = CompareOp_LE;
```

## Assembler Symbols

<V> Is a width specifier, encoded in “size”:



size	<V>
0x	RESERVED
10	RESERVED
11	D

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
integer element;
boolean test_passed;

for e = 0 to elements-1
    element = SInt(Elem[operand, e, esize]);
    case comparison of
        when CompareOp_GT test_passed = element > 0;
        when CompareOp_GE test_passed = element >= 0;
        when CompareOp_EQ test_passed = element == 0;
        when CompareOp_LE test_passed = element <= 0;
        when CompareOp_LT test_passed = element < 0;
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# CMLT (zero)

Compare signed Less than zero (vector). This instruction reads each vector element in the source SIMD&FP register and if the signed integer value is less than zero sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	size	1	0	0	0	0	0	0	1	0	1	0	1	0	Rn				Rd					

CMLT [<V>](#)[<d>](#), [<V>](#)[<n>](#), #0

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;

CompareOp comparison = CompareOp_LT;
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	size	1	0	0	0	0	0	0	1	0	1	0	1	0	Rn				Rd					

CMLT [<Vd>](#)[.<T>](#), [<Vn>](#)[.<T>](#), #0

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CompareOp comparison = CompareOp_LT;
```

## Assembler Symbols

[<V>](#) Is a width specifier, encoded in “size”:

size	<a href="#">&lt;V&gt;</a>
0x	RESERVED
10	RESERVED
11	D

[<d>](#) Is the number of the SIMD&FP destination register, encoded in the “Rd” field.

[<n>](#) Is the number of the SIMD&FP source register, encoded in the “Rn” field.

[<Vd>](#) Is the name of the SIMD&FP destination register, encoded in the “Rd” field.

[<T>](#) Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
integer element;
boolean test_passed;

for e = 0 to elements-1
    element = SInt(Elem[operand, e, esize]);
    case comparison of
        when CompareOp_GT test_passed = element > 0;
        when CompareOp_GE test_passed = element >= 0;
        when CompareOp_EQ test_passed = element == 0;
        when CompareOp_LE test_passed = element <= 0;
        when CompareOp_LT test_passed = element < 0;
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# CMTST

Compare bitwise Test bits nonzero (vector). This instruction reads each vector element in the first source SIMD&FP register, performs an AND with the corresponding vector element in the second source SIMD&FP register, and if the result is not zero, sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero. Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	size	1	Rm						1	0	0	0	1	1	Rn						Rd			
U																															

CMTST <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean and_test = (U == '0');
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	size	1	Rm						1	0	0	0	1	1	Rn						Rd			
U																															

CMTST <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean and_test = (U == '0');
```

## Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;
boolean test_passed;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    if and_test then
        test_passed = !IsZero(element1 AND element2);
    else
        test_passed = (element1 == element2);
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# CNT

Population Count per byte. This instruction counts the number of bits that have a value of one in each vector element in the source SIMD&FP register, places the result into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	size	1	0	0	0	0	0	0	0	1	0	1	1	0	Rn				Rd					

CNT <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size != '00' then UNDEFINED;
integer esize = 8;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV 8;
```

## Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	x	RESERVED
1x	x	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;

integer count;
for e = 0 to elements-1
    count = BitCount(Elem[operand, e, esize]);
    Elem[result, e, esize] = count<esize-1:0>;
V[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# DUP (element)

Duplicate vector element to vector or scalar. This instruction duplicates the vector element at the specified element index in the source SIMD&FP register into a scalar or each element in a vector, and writes the result to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This instruction is used by the alias [MOV \(scalar\)](#).

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	0	0	imm5					0	0	0	0	0	1	Rn					Rd				

DUP <V><d>, <Vn>.<T>[<index>]

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer size = LowestSetBit(imm5);
if size > 3 then UNDEFINED;

integer index = UInt(imm5<4:size+1>);
integer idxdsize = if imm5<4> == '1' then 128 else 64;

integer esize = 8 << size;
integer datasize = esize;
integer elements = 1;
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	0	0	imm5					0	0	0	0	0	1	Rn					Rd				

DUP <Vd>.<T>, <Vn>.<Ts>[<index>]

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer size = LowestSetBit(imm5);
if size > 3 then UNDEFINED;

integer index = UInt(imm5<4:size+1>);
integer idxdsize = if imm5<4> == '1' then 128 else 64;

if size == 3 && Q == '0' then UNDEFINED;
integer esize = 8 << size;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

## Assembler Symbols

<T> For the scalar variant: is the element width specifier, encoded in “imm5”:

<b>imm5</b>	<b>&lt;T&gt;</b>
x0000	RESERVED
xxxx1	B
xxx10	H
xx100	S
x1000	D

For the vector variant: is an arrangement specifier, encoded in "imm5:Q":

<b>imm5</b>	<b>Q</b>	<b>&lt;T&gt;</b>
x0000	x	RESERVED
xxxx1	0	8B
xxxx1	1	16B
xxx10	0	4H
xxx10	1	8H
xx100	0	2S
xx100	1	4S
x1000	0	RESERVED
x1000	1	2D

<Ts> Is an element size specifier, encoded in "imm5":

<b>imm5</b>	<b>&lt;Ts&gt;</b>
x0000	RESERVED
xxxx1	B
xxx10	H
xx100	S
x1000	D

<V> Is the destination width specifier, encoded in "imm5":

<b>imm5</b>	<b>&lt;V&gt;</b>
x0000	RESERVED
xxxx1	B
xxx10	H
xx100	S
x1000	D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<index> Is the element index encoded in "imm5":

<b>imm5</b>	<b>&lt;index&gt;</b>
x0000	RESERVED
xxxx1	imm5<4:1>
xxx10	imm5<4:2>
xx100	imm5<4:3>
x1000	imm5<4>

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(idxdsize) operand = V[n];
bits(datasize) result;
bits(esize) element;

element = Elem[operand, index, esize];
for e = 0 to elements-1
    Elem[result, e, esize] = element;
V[d] = result;

```



## Operational information

If PSTATE.DIT is 1:

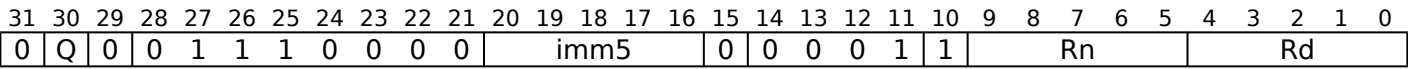
- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

DUP (general)

Duplicate general-purpose register to vector. This instruction duplicates the contents of the source general-purpose register into a scalar or each element in a vector, and writes the result to the SIMD&FP destination register. Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



DUP <Vd>.<T>, <R><n>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer size = LowestSetBit(imm5);
if size > 3 then UNDEFINED;

// imm5<4:size+1> is IGNORED

if size == 3 && Q == '0' then UNDEFINED;
integer esize = 8 << size;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "imm5:Q":

imm5	Q	<T>
x0000	x	RESERVED
xxx1	0	8B
xxx1	1	16B
xx10	0	4H
xx10	1	8H
xx100	0	2S
xx100	1	4S
x1000	0	RESERVED
x1000	1	2D

<R> Is the width specifier for the general-purpose source register, encoded in "imm5":

imm5	<R>
x0000	RESERVED
xxx1	W
xx10	W
xx100	W
x1000	X

Unspecified bits in "imm5" are ignored but should be set to zero by an assembler.

<n> Is the number [0-30] of the general-purpose source register or ZR (31), encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(esize) element = X[n];
bits(datasize) result;

for e = 0 to elements-1
    Elem[result, e, esize] = element;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

EOR3

Three-way Exclusive OR performs a three-way exclusive OR of the values in the three source SIMD&FP registers, and writes the result to the destination SIMD&FP register.

This instruction is implemented only when *FEAT\_SHA3* is implemented.

Advanced SIMD  
(FEAT\_SHA3)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	0	0	Rm				0	Ra				Rn				Rd							

EOR3 <Vd>.16B, <Vn>.16B, <Vm>.16B, <Va>.16B

```
if !HaveSHA3Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer a = UInt(Ra);
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Va> Is the name of the third SIMD&FP source register, encoded in the "Ra" field.

Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) Vm = V[m];
bits(128) Vn = V[n];
bits(128) Va = V[a];
V[d] = Vn EOR Vm EOR Va;
```

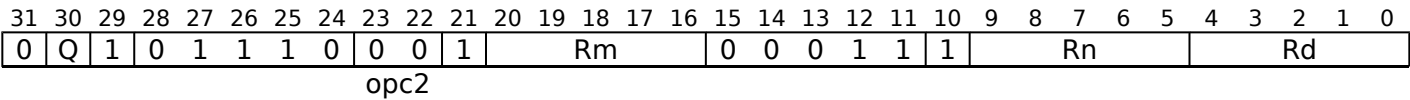
Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

EOR (vector)

Bitwise Exclusive OR (vector). This instruction performs a bitwise Exclusive OR operation between the two source SIMD&FP registers, and places the result in the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



EOR <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if Q == '1' then 128 else 64;
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "Q":

Q	<T>
0	8B
1	16B
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1;
bits(datasize) operand2;
bits(datasize) operand3;
bits(datasize) operand4 = V[n];

operand1 = V[m];
operand2 = Zeros();
operand3 = Ones();
V[d] = operand1 EOR ((operand2 EOR operand4) AND operand3);
```

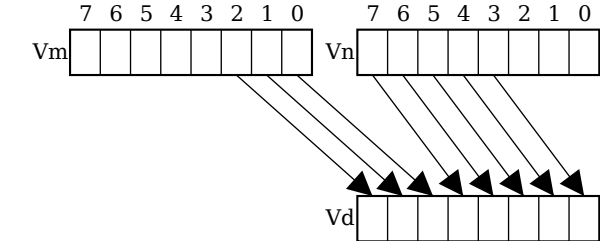
Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

EXT

Extract vector from pair of vectors. This instruction extracts the lowest vector elements from the second source SIMD&FP register and the highest vector elements from the first source SIMD&FP register, concatenates the results into a vector, and writes the vector to the destination SIMD&FP register vector. The index value specifies the lowest vector element to extract from the first source register, and consecutive elements are extracted from the first, then second, source registers until the destination vector is filled.

The following figure shows an example of the operation of EXT doubleword operation for Q = 0 and imm4<2:0> = 3.



Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	0	0	Rm				0	imm4				0	Rn				Rd						

EXT <Vd>.<T>, <Vn>.<T>, <Vm>.<T>, #<index>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if Q == '0' && imm4<3> == '1' then UNDEFINED;

integer datasize = if Q == '1' then 128 else 64;
integer position = UInt(imm4) << 3;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "Q":

Q	<T>
0	8B
1	16B

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

<index> Is the lowest numbered byte element to be extracted, encoded in "Q:imm4":

Q	imm4<3>	<index>
0	0	imm4<2:0>
0	1	RESERVED
1	x	imm4

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) hi = V[m];
bits(datasize) lo = V[n];
bits(datasize*2) concat = hi:lo;

V[d] = concat<position+datasize-1:position>;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FABD

Floating-point Absolute Difference (vector). This instruction subtracts the floating-point values in the elements of the second source SIMD&FP register, from the corresponding floating-point values in the elements of the first source SIMD&FP register, places the absolute value of each result in a vector, and writes the vector to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

Scalar half precision  
(FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	1	1	0	Rm				0	0	0	1	0	1	Rn				Rd						

FABD <Hd>, <Hn>, <Hm>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = esize;
integer elements = 1;
boolean abs = TRUE;
```

Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	1	sz	1	Rm				1	1	0	1	0	1	Rn				Rd						

FABD <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
boolean abs = TRUE;
```

Vector half precision  
(FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	1	0	Rm				0	0	0	1	0	1	Rn				Rd						

U

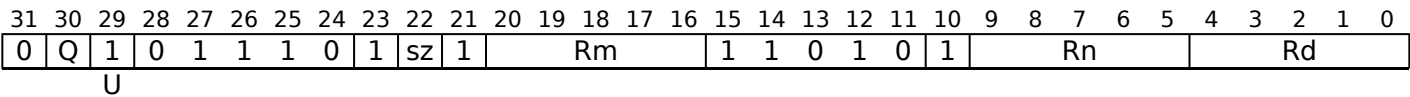


FABD <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean abs = (U == '1');
```

Vector single-precision and double-precision



FABD <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean abs = (U == '1');
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.

<V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];

bits(esize) element1;
bits(esize) element2;
bits(esize) diff;
FPCRTYPE fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[n] else Zeros();

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    diff = FPSub(element1, element2, fpcr);
    Elem[result, e, esize] = if abs then FPAbs(diff) else diff;

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

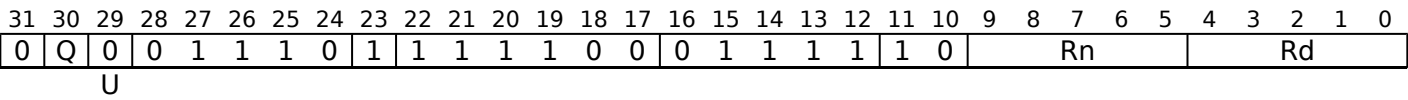
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FABS (vector)

Floating-point Absolute value (vector). This instruction calculates the absolute value of each vector element in the source SIMD&FP register, writes the result to a vector, and writes the vector to the destination SIMD&FP register. Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: Half-precision and Single-precision and double-precision

Half-precision  
(FEAT\_FP16)



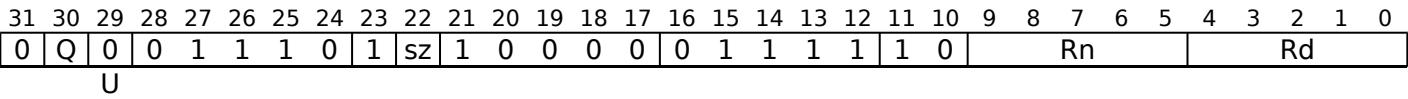
FABS <Vd>.<T>, <Vn>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean neg = (U == '1');
```

Single-precision and double-precision



FABS <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean neg = (U == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    if neg then
        element = FPNeg(element);
    else
        element = FPAbs(element);
    Elem[result, e, esize] = element;

V[d] = result;

```

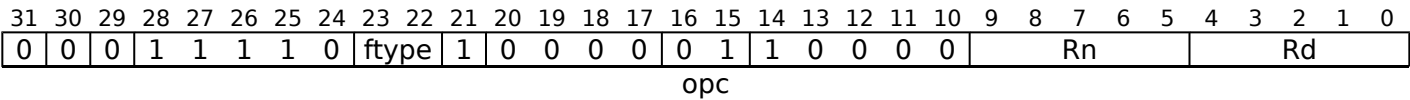
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FABS (scalar)

Floating-point Absolute value (scalar). This instruction calculates the absolute value in the SIMD&FP source register and writes the result to the SIMD&FP destination register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (FEAT\_FP16)

FABS <Hd>, <Hn>

## Single-precision (ftype == 00)

FABS <Sd>, <Sn>

## Double-precision (ftype == 01)

FABS <Dd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize;
case ftype of
  when '00' esize = 32;
  when '01' esize = 64;
  when '10' UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      esize = 16;
    else
      UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();

FPCRType fpcr = FPCR[];
boolean merge = IsMerging(fpcr);
bits(128) result = if merge then V[d] else Zeros();

bits(esize) operand = V[n];

Elem[result, 0, esize] = FPAbs(operand);
V[d] = result;
```



## FACGE

Floating-point Absolute Compare Greater than or Equal (vector). This instruction compares the absolute value of each floating-point value in the first source SIMD&FP register with the absolute value of the corresponding floating-point value in the second source SIMD&FP register and if the first value is greater than or equal to the second value sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

This instruction can generate a floating-point exception. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

### Scalar half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	0	1	0	Rm				0	0	1	0	1	1	Rn				Rd						
U								E			ac																				

FACGE <Hd>, <Hn>, <Hm>

```
if !HaveFP16Ext() then UNDEFINED;
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = esize;
integer elements = 1;
CompareOp cmp;
boolean abs;
```

```
case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

### Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	0	sz	1	Rm				1	1	1	0	1	1	Rn				Rd						
U								E			ac																				

FACGE <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

## Vector half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	1	0	Rm				0	0	1	0	1	1	Rn				Rd						
U								E								ac															

FACGE <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

## Vector single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	sz	1	Rm					1	1	1	0	1	1	Rn					Rd				
U								E								ac															



**FACGE** <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

### Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];

bits(esize) element1;
bits(esize) element2;
boolean test_passed;
FPCRType fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[m] else Zeros();

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    if abs then
        element1 = FPAbs(element1);
        element2 = FPAbs(element2);
    case cmp of
        when CompareOp_EQ test_passed = FPCompareEQ(element1, element2, fpcr);
        when CompareOp_GE test_passed = FPCompareGE(element1, element2, fpcr);
        when CompareOp_GT test_passed = FPCompareGT(element1, element2, fpcr);
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FACGT

Floating-point Absolute Compare Greater than (vector). This instruction compares the absolute value of each vector element in the first source SIMD&FP register with the absolute value of the corresponding vector element in the second source SIMD&FP register and if the first value is greater than the second value sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	1	1	0	Rm				0	0	1	0	1	1	Rn				Rd						
U								E			ac																				

FACGT <Hd>, <Hn>, <Hm>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = esize;
integer elements = 1;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_E0; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

## Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	1	sz	1	Rm				1	1	1	0	1	1	Rn				Rd						
U								E			ac																				

FACGT <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

## Vector half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	1	0	Rm				0	0	1	0	1	1	Rn				Rd						
U								E								ac															

FACGT <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

## Vector single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	sz	1	Rm					1	1	1	0	1	1	Rn					Rd				
U								E								ac															

**FACGT** <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

### Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];

bits(esize) element1;
bits(esize) element2;
boolean test_passed;
FPCRType fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[m] else Zeros();

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    if abs then
        element1 = FPAbs(element1);
        element2 = FPAbs(element2);
    case cmp of
        when CompareOp_EQ test_passed = FPCompareEQ(element1, element2, fpcr);
        when CompareOp_GE test_passed = FPCompareGE(element1, element2, fpcr);
        when CompareOp_GT test_passed = FPCompareGT(element1, element2, fpcr);
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FADD (vector)

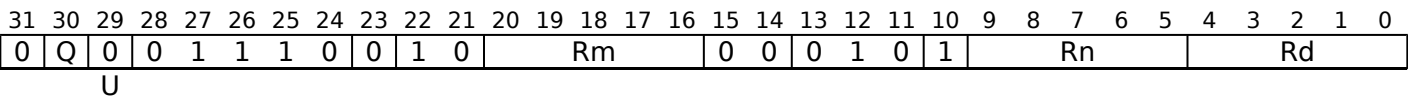
Floating-point Add (vector). This instruction adds corresponding vector elements in the two source SIMD&FP registers, writes the result into a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are floating-point values.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

Half-precision  
(FEAT\_FP16)



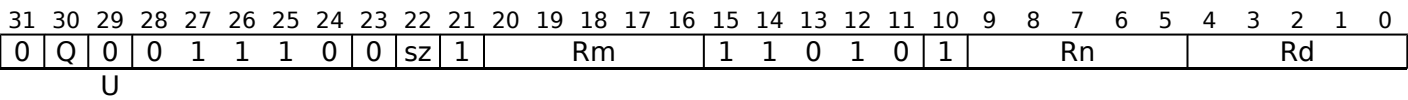
FADD <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
```

Single-precision and double-precision



FADD <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(2*datasize) concat = operand2:operand1;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    if pair then
        element1 = Elem[concat, 2*e, esize];
        element2 = Elem[concat, (2*e)+1, esize];
    else
        element1 = Elem[operand1, e, esize];
        element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = FPAdd(element1, element2, FPCR[]);

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

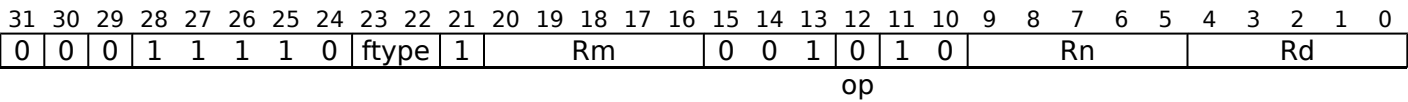


# FADD (scalar)

Floating-point Add (scalar). This instruction adds the floating-point values of the two source SIMD&FP registers, and writes the result to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (FEAT\_FP16)

FADD <Hd>, <Hn>, <Hm>

## Single-precision (ftype == 00)

FADD <Sd>, <Sn>, <Sm>

## Double-precision (ftype == 01)

FADD <Dd>, <Dn>, <Dm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer esize;
case ftype of
    when '00' esize = 32;
    when '01' esize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            esize = 16;
        else
            UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Dm> Is the 64-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Sm> Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
bits(esize) operand1 = V[n];  
bits(esize) operand2 = V[m];  
  
FPCRTYPE fpcr = FPCR[];  
boolean merge = IsMerging(fpcr);  
bits(128) result = if merge then V[n] else Zeros();  
  
Elem[result, 0, esize] = FPAAdd(operand1, operand2, fpcr);  
  
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FADDP (scalar)

Floating-point Add Pair of elements (scalar). This instruction adds two floating-point vector elements in the source SIMD&FP register and writes the scalar result into the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	sz	1	1	0	0	0	0	1	1	0	1	1	0	Rn				Rd					

FADDP <V><d>, <Vn>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer esize = 16;
if sz == '1' then UNDEFINED;
integer datasize = 32;
```

## Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	0	sz	1	1	0	0	0	0	1	1	0	1	1	0	Rn				Rd					

FADDP <V><d>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize * 2;
```

## Assembler Symbols

- <V>

For the half-precision variant: is the destination width specifier, encoded in “sz”:

sz	<V>
0	H
1	RESERVED
- For the single-precision and double-precision variant: is the destination width specifier, encoded in “sz”:

sz	<V>
0	S
1	D
- <d>

Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vn>

Is the name of the SIMD&FP source register, encoded in the "Rn" field.
- <T>

For the half-precision variant: is the source arrangement specifier, encoded in “sz”:

sz	<T>
0	2H
1	RESERVED

For the single-precision and double-precision variant: is the source arrangement specifier, encoded in “SZ”:

sz	<T>
0	2S
1	2D

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
V[d] = Reduce(ReduceOp_FADD, operand, esize);

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## FADDP (vector)

Floating-point Add Pairwise (vector). This instruction creates a vector by concatenating the vector elements of the first source SIMD&FP register after the vector elements of the second source SIMD&FP register, reads each pair of adjacent vector elements from the concatenated vector, adds each pair of values together, places the result into a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are floating-point values.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

### Half-precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	1	0	Rm					0	0	0	1	0	1	Rn					Rd				
U																															

FADDP <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
```

### Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	sz	1	Rm				1	1	0	1	0	1	Rn				Rd						
U																															

FADDP <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
```

### Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(2*datasize) concat = operand2:operand1;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    if pair then
        element1 = Elem[concat, 2*e, esize];
        element2 = Elem[concat, (2*e)+1, esize];
    else
        element1 = Elem[operand1, e, esize];
        element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = FPAAdd(element1, element2, FPCR[]);

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FCADD

Floating-point Complex Add.

This instruction operates on complex numbers that are represented in SIMD&FP registers as pairs of elements, with the more significant element holding the imaginary part of the number and the less significant element holding the real part of the number. Each element holds a floating-point value. It performs the following computation on the corresponding complex number element pairs from the two source registers:

- Considering the complex number from the second source register on an Argand diagram, the number is rotated counterclockwise by 90 or 270 degrees.
- The rotated complex number is added to the complex number from the first source register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

Vector  
(FEAT\_FCMA)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	size	0	Rm			1	1	1	rot	0	1	Rn			Rd									

FCADD <Vd>.<T>, <Vn>.<T>, <Vm>.<T>, #<rotate>

```
if !HaveFCADDExt() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '00' then UNDEFINED;
if Q == '0' && size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
if !HaveFP16Ext() && esize == 16 then UNDEFINED;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

<rotate> Is the rotation, encoded in "rot":

rot	<rotate>
0	90
1	270

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
bits(esize) element1;
bits(esize) element3;

for e = 0 to (elements DIV 2)-1
    case rot of
        when '0'
            element1 = FPNeg(Elem[operand2, e*2+1, esize]);
            element3 = Elem[operand2, e*2, esize];
        when '1'
            element1 = Elem[operand2, e*2+1, esize];
            element3 = FPNeg(Elem[operand2, e*2, esize]);
    Elem[result, e*2, esize] = FPAAdd(Elem[operand1, e*2, esize], element1, FPCR[]);
    Elem[result, e*2+1, esize] = FPAAdd(Elem[operand1, e*2+1, esize], element3, FPCR[]);
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



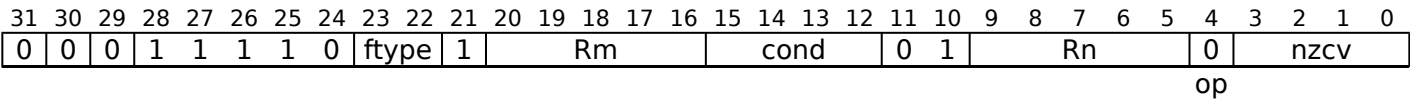
# FCCMP

Floating-point Conditional quiet Compare (scalar). This instruction compares the two SIMD&FP source register values and writes the result to the *PSTATE*.{N, Z, C, V} flags. If the condition does not pass then the *PSTATE*.{N, Z, C, V} flags are set to the flag bit specifier.

This instruction raises an Invalid Operation floating-point exception if either or both of the operands is a signaling NaN.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (FEAT\_FP16)

FCCMP <Hn>, <Hm>, #<nzcw>, <cond>

## Single-precision (ftype == 00)

FCCMP <Sn>, <Sm>, #<nzcw>, <cond>

## Double-precision (ftype == 01)

FCCMP <Dn>, <Dm>, #<nzcw>, <cond>

```
integer n = UInt(Rn);
integer m = UInt(Rm);

integer datasize;
case ftype of
    when '00' datasize = 32;
    when '01' datasize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            datasize = 16;
        else
            UNDEFINED;

bits(4) flags = nzcw;
```

## Assembler Symbols

- <Dn> Is the 64-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Dm> Is the 64-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Sn> Is the 32-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Sm> Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <nzcw> Is the flag bit specifier, an immediate in the range 0 to 15, giving the alternative state for the 4-bit NZCV condition flags, encoded in the "nzcw" field.
- <cond> Is one of the standard conditions, encoded in the "cond" field in the standard way.

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(datasize) operand1 = V[n];
bits(datasize) operand2;

operand2 = V[m];

if ConditionHolds(cond) then
    flags = FPCompare(operand1, operand2, FALSE, FPCR[]);
PSTATE.<N,Z,C,V> = flags;
```

## Operational information

The IEEE 754 standard specifies that the result of a comparison is precisely one of <, ==, > or unordered. If either or both of the operands is a NaN, they are unordered, and all three of (Operand1 < Operand2), (Operand1 == Operand2) and (Operand1 > Operand2) are false. An unordered comparison sets the *PSTATE* condition flags to N=0, Z=0, C=1, and V=1.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

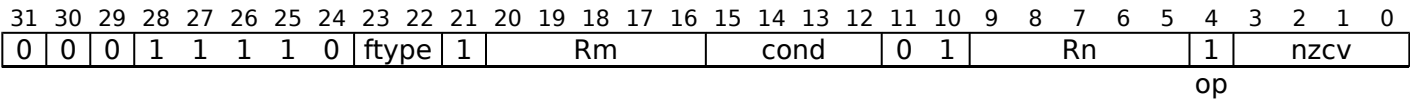
# FCCMPE

Floating-point Conditional signaling Compare (scalar). This instruction compares the two SIMD&FP source register values and writes the result to the *PSTATE*.{N, Z, C, V} flags. If the condition does not pass then the *PSTATE*.{N, Z, C, V} flags are set to the flag bit specifier.

This instruction raises an Invalid Operation floating-point exception if either or both of the operands is any type of NaN.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (FEAT\_FP16)

FCCMPE <Hn>, <Hm>, #<nzcvcv>, <cond>

## Single-precision (ftype == 00)

FCCMPE <Sn>, <Sm>, #<nzcvcv>, <cond>

## Double-precision (ftype == 01)

FCCMPE <Dn>, <Dm>, #<nzcvcv>, <cond>

```
integer n = UInt(Rn);
integer m = UInt(Rm);

integer datasize;
case ftype of
    when '00' datasize = 32;
    when '01' datasize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            datasize = 16;
        else
            UNDEFINED;

bits(4) flags = nzcvcv;
```

## Assembler Symbols

- <Dn> Is the 64-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Dm> Is the 64-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Sn> Is the 32-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Sm> Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <nzcvcv> Is the flag bit specifier, an immediate in the range 0 to 15, giving the alternative state for the 4-bit NZCV condition flags, encoded in the "nzcvcv" field.
- <cond> Is one of the standard conditions, encoded in the "cond" field in the standard way.

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(datasize) operand1 = V[n];
bits(datasize) operand2;

operand2 = V[m];

if ConditionHolds(cond) then
    flags = FPCompare(operand1, operand2, TRUE, FPCR[]);
PSTATE.<N,Z,C,V> = flags;
```

## Operational information

The IEEE 754 standard specifies that the result of a comparison is precisely one of <, ==, > or unordered. If either or both of the operands is a NaN, they are unordered, and all three of (Operand1 < Operand2), (Operand1 == Operand2) and (Operand1 > Operand2) are false. An unordered comparison sets the *PSTATE* condition flags to N=0, Z=0, C=1, and V=1.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## FCMEQ (register)

Floating-point Compare Equal (vector). This instruction compares each floating-point value from the first source SIMD&FP register, with the corresponding floating-point value from the second source SIMD&FP register, and if the comparison is equal sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

### Scalar half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	1	0	Rm				0	0	1	0	0	1	Rn				Rd						
U								E				ac																			

FCMEQ <Hd>, <Hn>, <Hm>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = esize;
integer elements = 1;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

### Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	sz	1	Rm				1	1	1	0	0	1	Rn				Rd						
U								E				ac																			

FCMEQ <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

## Vector half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	1	0	Rm				0	0	1	0	0	1	Rn				Rd						
U								E								ac															

FCMEQ <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

## Vector single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	sz	1	Rm					1	1	1	0	0	1	Rn					Rd				
U								E								ac															

FCMEQ <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

### Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];

bits(esize) element1;
bits(esize) element2;
boolean test_passed;
FPCRType fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[m] else Zeros();

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    if abs then
        element1 = FPAbs(element1);
        element2 = FPAbs(element2);
    case cmp of
        when CompareOp_EQ test_passed = FPCompareEQ(element1, element2, fpcr);
        when CompareOp_GE test_passed = FPCompareGE(element1, element2, fpcr);
        when CompareOp_GT test_passed = FPCompareGT(element1, element2, fpcr);
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# FCMEQ (zero)

Floating-point Compare Equal to zero (vector). This instruction reads each floating-point value in the source SIMD&FP register and if the value is equal to zero sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

This instruction can generate a floating-point exception. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	1	1	1	1	0	0	0	1	1	0	1	1	0	Rn				Rd						
U										op																					

FCMEQ <Hd>, <Hn>, #0.0

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;

CompareOp comparison;
case op:U of
    when '00' comparison = CompareOp_GT;
    when '01' comparison = CompareOp_GE;
    when '10' comparison = CompareOp_EQ;
    when '11' comparison = CompareOp_LE;
```

## Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	1	sz	1	0	0	0	0	0	1	1	0	1	1	0	Rn				Rd					
U										op																					

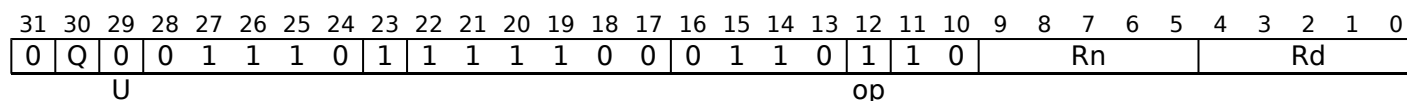
FCMEQ <V><d>, <V><n>, #0.0

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;

CompareOp comparison;
case op:U of
    when '00' comparison = CompareOp_GT;
    when '01' comparison = CompareOp_GE;
    when '10' comparison = CompareOp_EQ;
    when '11' comparison = CompareOp_LE;
```

## Vector half precision (FEAT\_FP16)



FCMEQ <Vd>.<T>, <Vn>.<T>, #0.0

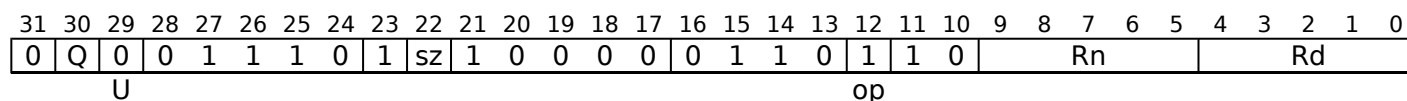
```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CompareOp comparison;
case op:U of
    when '00' comparison = CompareOp_GT;
    when '01' comparison = CompareOp_GE;
    when '10' comparison = CompareOp_EQ;
    when '11' comparison = CompareOp_LE;
```

## Vector single-precision and double-precision



FCMEQ <Vd>.<T>, <Vn>.<T>, #0.0

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CompareOp comparison;
case op:U of
    when '00' comparison = CompareOp_GT;
    when '01' comparison = CompareOp_GE;
    when '10' comparison = CompareOp_EQ;
    when '11' comparison = CompareOp_LE;
```

## Assembler Symbols

<Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.

<Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.

<V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in “Q”:

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in “sz:Q”:

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) zero = FPZero('0');
bits(esize) element;
boolean test_passed;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    case comparison of
        when CompareOp_GT test_passed = FPCompareGT(element, zero, FPCR[]);
        when CompareOp_GE test_passed = FPCompareGE(element, zero, FPCR[]);
        when CompareOp_EQ test_passed = FPCompareEQ(element, zero, FPCR[]);
        when CompareOp_LE test_passed = FPCompareLE(zero, element, FPCR[]);
        when CompareOp_LT test_passed = FPCompareLT(zero, element, FPCR[]);
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## FCMGE (register)

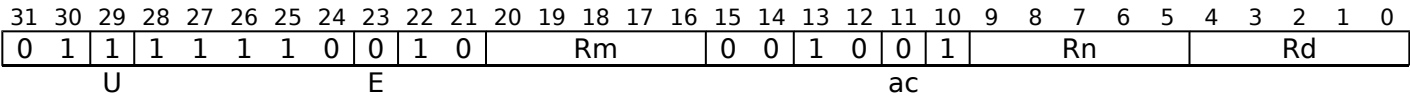
Floating-point Compare Greater than or Equal (vector). This instruction reads each floating-point value in the first source SIMD&FP register and if the value is greater than or equal to the corresponding floating-point value in the second source SIMD&FP register sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

### Scalar half precision (FEAT\_FP16)



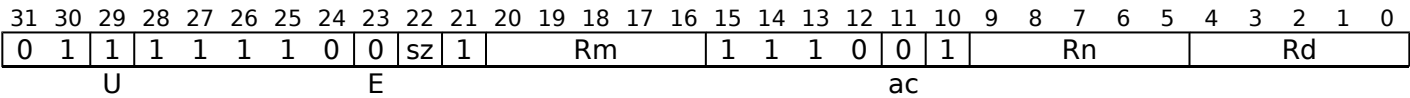
FCMGE <Hd>, <Hn>, <Hm>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = esize;
integer elements = 1;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_E0; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

### Scalar single-precision and double-precision



FCMGE <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

## Vector half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	1	0	Rm				0	0	1	0	0	1	Rn				Rd						
U								E								ac															

FCMGE <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

## Vector single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	sz	1	Rm					1	1	1	0	0	1	Rn					Rd				
U								E								ac															

FCMGE <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

### Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];

bits(esize) element1;
bits(esize) element2;
boolean test_passed;
FPCRType fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[m] else Zeros();

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    if abs then
        element1 = FPAbs(element1);
        element2 = FPAbs(element2);
    case cmp of
        when CompareOp_EQ test_passed = FPCompareEQ(element1, element2, fpcr);
        when CompareOp_GE test_passed = FPCompareGE(element1, element2, fpcr);
        when CompareOp_GT test_passed = FPCompareGT(element1, element2, fpcr);
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## FCMGE (zero)

Floating-point Compare Greater than or Equal to zero (vector). This instruction reads each floating-point value in the source SIMD&FP register and if the value is greater than or equal to zero sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

This instruction can generate a floating-point exception. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#), [Scalar single-precision and double-precision](#), [Vector half precision](#) and [Vector single-precision and double-precision](#)

### Scalar half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	1	1	1	1	1	0	0	0	1	1	0	0	1	0	Rn				Rd					
U										op																					

FCMGE <Hd>, <Hn>, #0.0

```
if !HaveFP16Ext() then UNDEFINED;
```

```
integer d = UInt(Rd);
```

```
integer n = UInt(Rn);
```

```
integer esize = 16;
```

```
integer datasize = esize;
```

```
integer elements = 1;
```

```
CompareOp comparison;
```

```
case op:U of
```

```
    when '00' comparison = CompareOp\_GT;
```

```
    when '01' comparison = CompareOp\_GE;
```

```
    when '10' comparison = CompareOp\_EQ;
```

```
    when '11' comparison = CompareOp\_LE;
```

### Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	1	sz	1	0	0	0	0	0	1	1	0	0	1	0	Rn					Rd				
U										op																					

FCMGE <V><d>, <V><n>, #0.0

```
integer d = UInt(Rd);
```

```
integer n = UInt(Rn);
```

```
integer esize = 32 << UInt(sz);
```

```
integer datasize = esize;
```

```
integer elements = 1;
```

```
CompareOp comparison;
```

```
case op:U of
```

```
    when '00' comparison = CompareOp\_GT;
```

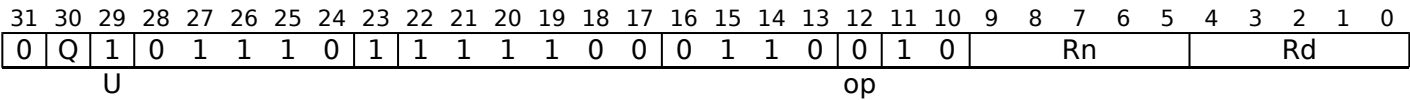
```
    when '01' comparison = CompareOp\_GE;
```

```
    when '10' comparison = CompareOp\_EQ;
```

```
    when '11' comparison = CompareOp\_LE;
```



Vector half precision  
(FEAT\_FP16)



FCMGE <Vd>.<T>, <Vn>.<T>, #0.0

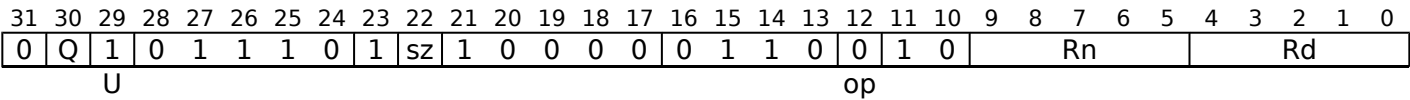
```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CompareOp comparison;
case op:U of
    when '00' comparison = CompareOp_GT;
    when '01' comparison = CompareOp_GE;
    when '10' comparison = CompareOp_EQ;
    when '11' comparison = CompareOp_LE;
```

Vector single-precision and double-precision



FCMGE <Vd>.<T>, <Vn>.<T>, #0.0

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CompareOp comparison;
case op:U of
    when '00' comparison = CompareOp_GT;
    when '01' comparison = CompareOp_GE;
    when '10' comparison = CompareOp_EQ;
    when '11' comparison = CompareOp_LE;
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D
- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in “Q”:

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in “sz:Q”:

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) zero = FPZero('0');
bits(esize) element;
boolean test_passed;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    case comparison of
        when CompareOp_GT test_passed = FPCompareGT(element, zero, FPCR[]);
        when CompareOp_GE test_passed = FPCompareGE(element, zero, FPCR[]);
        when CompareOp_EQ test_passed = FPCompareEQ(element, zero, FPCR[]);
        when CompareOp_LE test_passed = FPCompareLE(zero, element, FPCR[]);
        when CompareOp_LT test_passed = FPCompareLT(zero, element, FPCR[]);
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## FCMGT (register)

Floating-point Compare Greater than (vector). This instruction reads each floating-point value in the first source SIMD&FP register and if the value is greater than the corresponding floating-point value in the second source SIMD&FP register sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

### Scalar half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	1	1	0	Rm				0	0	1	0	0	1	Rn				Rd						
U								E				ac																			

FCMGT <Hd>, <Hn>, <Hm>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = esize;
integer elements = 1;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

### Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	1	sz	1	Rm				1	1	1	0	0	1	Rn				Rd						
U								E				ac																			

FCMGT <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

## Vector half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	1	0	Rm				0	0	1	0	0	1	Rn				Rd						
U								E								ac															

FCMGT <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

## Vector single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	sz	1	Rm				1	1	1	0	0	1	Rn				Rd						
U								E								ac															

FCMGT <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];

bits(esize) element1;
bits(esize) element2;
boolean test_passed;
FPCRType fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[m] else Zeros();

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    if abs then
        element1 = FPAbs(element1);
        element2 = FPAbs(element2);
    case cmp of
        when CompareOp_EQ test_passed = FPCompareEQ(element1, element2, fpcr);
        when CompareOp_GE test_passed = FPCompareGE(element1, element2, fpcr);
        when CompareOp_GT test_passed = FPCompareGT(element1, element2, fpcr);
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## FCMGT (zero)

Floating-point Compare Greater than zero (vector). This instruction reads each floating-point value in the source SIMD&FP register and if the value is greater than zero sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

This instruction can generate a floating-point exception. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#), [Scalar single-precision and double-precision](#), [Vector half precision](#) and [Vector single-precision and double-precision](#)

### Scalar half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	1	1	1	1	1	0	0	0	1	1	0	0	1	0	Rn				Rd					
U										op																					

FCMGT <Hd>, <Hn>, #0.0

```
if !HaveFP16Ext() then UNDEFINED;
```

```
integer d = UInt(Rd);  
integer n = UInt(Rn);
```

```
integer esize = 16;  
integer datasize = esize;  
integer elements = 1;
```

[CompareOp](#) comparison;

case op:U of

```
when '00' comparison = CompareOp\_GT;  
when '01' comparison = CompareOp\_GE;  
when '10' comparison = CompareOp\_EQ;  
when '11' comparison = CompareOp\_LE;
```

### Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	1	sz	1	0	0	0	0	0	1	1	0	0	1	0	Rn				Rd					
U										op																					

FCMGT <V><d>, <V><n>, #0.0

```
integer d = UInt(Rd);  
integer n = UInt(Rn);
```

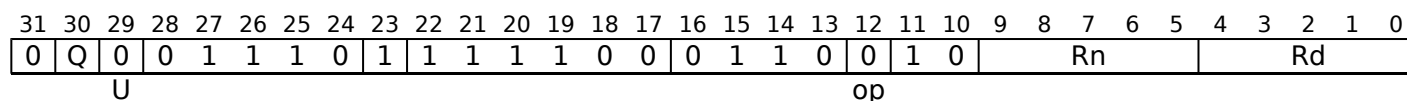
```
integer esize = 32 << UInt(sz);  
integer datasize = esize;  
integer elements = 1;
```

[CompareOp](#) comparison;

case op:U of

```
when '00' comparison = CompareOp\_GT;  
when '01' comparison = CompareOp\_GE;  
when '10' comparison = CompareOp\_EQ;  
when '11' comparison = CompareOp\_LE;
```

## Vector half precision (FEAT\_FP16)



FCMGT <Vd>.<T>, <Vn>.<T>, #0.0

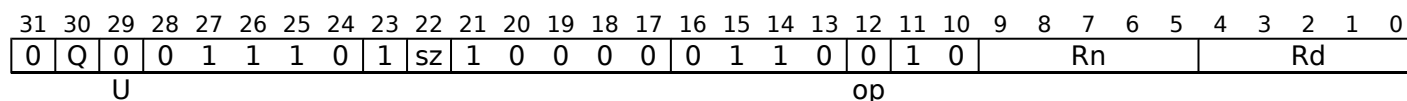
```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CompareOp comparison;
case op:U of
    when '00' comparison = CompareOp_GT;
    when '01' comparison = CompareOp_GE;
    when '10' comparison = CompareOp_EQ;
    when '11' comparison = CompareOp_LE;
```

## Vector single-precision and double-precision



FCMGT <Vd>.<T>, <Vn>.<T>, #0.0

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CompareOp comparison;
case op:U of
    when '00' comparison = CompareOp_GT;
    when '01' comparison = CompareOp_GE;
    when '10' comparison = CompareOp_EQ;
    when '11' comparison = CompareOp_LE;
```

## Assembler Symbols

<Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.

<Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.

<V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.



<T> For the half-precision variant: is an arrangement specifier, encoded in “Q”:

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in “sz:Q”:

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) zero = FPZero('0');
bits(esize) element;
boolean test_passed;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    case comparison of
        when CompareOp_GT test_passed = FPCompareGT(element, zero, FPCR[]);
        when CompareOp_GE test_passed = FPCompareGE(element, zero, FPCR[]);
        when CompareOp_EQ test_passed = FPCompareEQ(element, zero, FPCR[]);
        when CompareOp_LE test_passed = FPCompareLE(zero, element, FPCR[]);
        when CompareOp_LT test_passed = FPCompareLT(zero, element, FPCR[]);
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FCMLA (by element)

Floating-point Complex Multiply Accumulate (by element).  
This instruction operates on complex numbers that are represented in SIMD&FP registers as pairs of elements, with the more significant element holding the imaginary part of the number and the less significant element holding the real part of the number. Each element holds a floating-point value. It performs the following computation on complex numbers from the first source register and the destination register with the specified complex number from the second source register:

- Considering the complex number from the second source register on an Argand diagram, the number is rotated counterclockwise by 0, 90, 180, or 270 degrees.
- The two elements of the transformed complex number are multiplied by:
  - The real element of the complex number from the first source register, if the transformation was a rotation by 0 or 180 degrees.
  - The imaginary element of the complex number from the first source register, if the transformation was a rotation by 90 or 270 degrees.
- The complex number resulting from that multiplication is added to the complex number from the destination register.

The multiplication and addition operations are performed as a fused multiply-add, without any intermediate rounding. This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

## Vector (FEAT\_FCMA)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	size	L	M		Rm		0	rot	1	H	0													Rd

(size == 01)

```
FCMLA <Vd>.<T>, <Vn>.<T>, <Vm>.<Ts>[<index>], #<rotate>
```

(size == 10)

```
FCMLA <Vd>.<T>, <Vn>.<T>, <Vm>.<Ts>[<index>], #<rotate>
```

```
if !HaveFCADDExt() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(M:Rm);
if size == '00' || size == '11' then UNDEFINED;
if size == '01' then index = UInt(H:L);
if size == '10' then index = UInt(H);
integer esize = 8 << UInt(size);
if !HaveFP16Ext() && esize == 16 then UNDEFINED;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
if size == '10' && (L == '1' || Q == '0') then UNDEFINED;
if size == '01' && H == '1' && Q == '0' then UNDEFINED;
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	RESERVED
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "M:Rm" fields.

<Ts> Is an element size specifier, encoded in "size":

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in "size:H:L":

size	<index>
00	RESERVED
01	H:L
10	H
11	RESERVED

<rotate> Is the rotation, encoded in "rot":

rot	<rotate>
00	0
01	90
10	180
11	270

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
FPCRTYPE fpcr = FPCR[];

for e = 0 to (elements DIV 2)-1
  case rot of
    when '00'
      element1 = Elem[operand2, index*2, esize];
      element2 = Elem[operand1, e*2, esize];
      element3 = Elem[operand2, index*2+1, esize];
      element4 = Elem[operand1, e*2+1, esize];
    when '01'
      element1 = FPNeg(Elem[operand2, index*2+1, esize]);
      element2 = Elem[operand1, e*2+1, esize];
      element3 = Elem[operand2, index*2, esize];
      element4 = Elem[operand1, e*2+1, esize];
    when '10'
      element1 = FPNeg(Elem[operand2, index*2, esize]);
      element2 = Elem[operand1, e*2, esize];
      element3 = FPNeg(Elem[operand2, index*2+1, esize]);
      element4 = Elem[operand1, e*2, esize];
    when '11'
      element1 = Elem[operand2, index*2+1, esize];
      element2 = Elem[operand1, e*2+1, esize];
      element3 = FPNeg(Elem[operand2, index*2, esize]);
      element4 = Elem[operand1, e*2+1, esize];

  Elem[result, e*2, esize] = FPMulAdd(Elem[operand3, e*2, esize], element2, element1, fpcr);
  Elem[result, e*2+1, esize] = FPMulAdd(Elem[operand3, e*2+1, esize], element4, element3, fpcr);

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FCMLA

Floating-point Complex Multiply Accumulate.

This instruction operates on complex numbers that are represented in SIMD&FP registers as pairs of elements, with the more significant element holding the imaginary part of the number and the less significant element holding the real part of the number. Each element holds a floating-point value. It performs the following computation on the corresponding complex number element pairs from the two source registers and the destination register:

- Considering the complex number from the second source register on an Argand diagram, the number is rotated counterclockwise by 0, 90, 180, or 270 degrees.
- The two elements of the transformed complex number are multiplied by:
  - The real element of the complex number from the first source register, if the transformation was a rotation by 0 or 180 degrees.
  - The imaginary element of the complex number from the first source register, if the transformation was a rotation by 90 or 270 degrees.
- The complex number resulting from that multiplication is added to the complex number from the destination register.

The multiplication and addition operations are performed as a fused multiply-add, without any intermediate rounding. This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

Vector  
(FEAT\_FCMA)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	size	0				Rm			1	1	0	rot	1				Rn					Rd		

FCMLA <Vd>.<T>, <Vn>.<T>, <Vm>.<T>, #<rotate>

```
if !HaveFCADDExt() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '00' then UNDEFINED;
if Q == '0' && size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
if !HaveFP16Ext() && esize == 16 then UNDEFINED;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

<rotate> Is the rotation, encoded in "rot":

rot	<rotate>
00	0
01	90
10	180
11	270

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;
bits(esize) element3;
bits(esize) element4;
FPCRType fpcr = FPCR[];

for e = 0 to (elements DIV 2)-1
    case rot of
        when '00'
            element1 = Elem[operand2, e*2, esize];
            element2 = Elem[operand1, e*2, esize];
            element3 = Elem[operand2, e*2+1, esize];
            element4 = Elem[operand1, e*2+1, esize];
        when '01'
            element1 = FPNeg(Elem[operand2, e*2+1, esize]);
            element2 = Elem[operand1, e*2+1, esize];
            element3 = Elem[operand2, e*2, esize];
            element4 = Elem[operand1, e*2+1, esize];
        when '10'
            element1 = FPNeg(Elem[operand2, e*2, esize]);
            element2 = Elem[operand1, e*2, esize];
            element3 = FPNeg(Elem[operand2, e*2+1, esize]);
            element4 = Elem[operand1, e*2, esize];
        when '11'
            element1 = Elem[operand2, e*2+1, esize];
            element2 = Elem[operand1, e*2+1, esize];
            element3 = FPNeg(Elem[operand2, e*2, esize]);
            element4 = Elem[operand1, e*2+1, esize];

    Elem[result, e*2, esize] = FPMulAdd(Elem[operand3, e*2, esize], element2, element1, fpcr);
    Elem[result, e*2+1, esize] = FPMulAdd(Elem[operand3, e*2+1, esize], element4, element3, fpcr);

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## FCMLE (zero)

Floating-point Compare Less than or Equal to zero (vector). This instruction reads each floating-point value in the source SIMD&FP register and if the value is less than or equal to zero sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

This instruction can generate a floating-point exception. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

### Scalar half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	1	1	1	1	1	0	0	0	1	1	0	1	1	0	Rn				Rd					
U										op																					

FCMLE <Hd>, <Hn>, #0.0

```
if !HaveFP16Ext() then UNDEFINED;
```

```
integer d = UInt(Rd);  
integer n = UInt(Rn);
```

```
integer esize = 16;  
integer datasize = esize;  
integer elements = 1;
```

[CompareOp](#) comparison;

case op:U of

```
when '00' comparison = CompareOp\_GT;  
when '01' comparison = CompareOp\_GE;  
when '10' comparison = CompareOp\_EQ;  
when '11' comparison = CompareOp\_LE;
```

### Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	0	1	sz	1	0	0	0	0	0	0	1	1	0	1	1	0	Rn				Rd					
U										op																					

FCMLE <V><d>, <V><n>, #0.0

```
integer d = UInt(Rd);  
integer n = UInt(Rn);
```

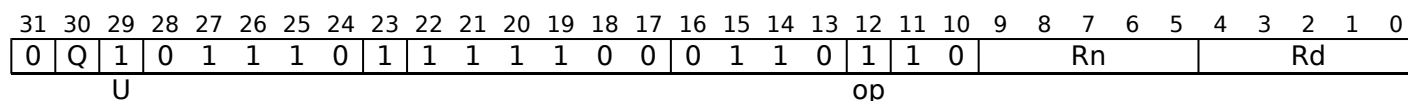
```
integer esize = 32 << UInt(sz);  
integer datasize = esize;  
integer elements = 1;
```

[CompareOp](#) comparison;

case op:U of

```
when '00' comparison = CompareOp\_GT;  
when '01' comparison = CompareOp\_GE;  
when '10' comparison = CompareOp\_EQ;  
when '11' comparison = CompareOp\_LE;
```

## Vector half precision (FEAT\_FP16)



**FCMLE** <Vd>.<T>, <Vn>.<T>, #0.0

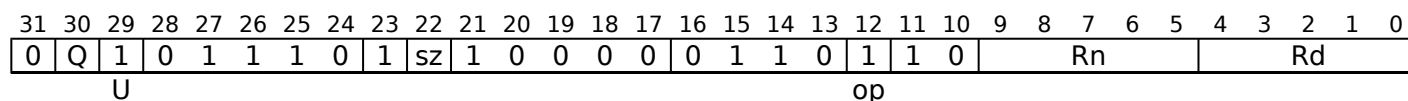
```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CompareOp comparison;
case op:U of
    when '00' comparison = CompareOp_GT;
    when '01' comparison = CompareOp_GE;
    when '10' comparison = CompareOp_EQ;
    when '11' comparison = CompareOp_LE;
```

## Vector single-precision and double-precision



**FCMLE** <Vd>.<T>, <Vn>.<T>, #0.0

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CompareOp comparison;
case op:U of
    when '00' comparison = CompareOp_GT;
    when '01' comparison = CompareOp_GE;
    when '10' comparison = CompareOp_EQ;
    when '11' comparison = CompareOp_LE;
```

## Assembler Symbols

<Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.

<Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.

<V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.



<T> For the half-precision variant: is an arrangement specifier, encoded in “Q”:

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in “sz:Q”:

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) zero = FPZero('0');
bits(esize) element;
boolean test_passed;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    case comparison of
        when CompareOp_GT test_passed = FPCompareGT(element, zero, FPCR[]);
        when CompareOp_GE test_passed = FPCompareGE(element, zero, FPCR[]);
        when CompareOp_EQ test_passed = FPCompareEQ(element, zero, FPCR[]);
        when CompareOp_LE test_passed = FPCompareLE(zero, element, FPCR[]);
        when CompareOp_LT test_passed = FPCompareLT(zero, element, FPCR[]);
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## FCMLT (zero)

Floating-point Compare Less than zero (vector). This instruction reads each floating-point value in the source SIMD&FP register and if the value is less than zero sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

This instruction can generate a floating-point exception. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

### Scalar half precision

(FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	1	0	1	1	1	1	0	1	1	1	1	1	0	0	0	1	1	1	0	1	0	Rn						Rd					

FCMLT [<Hd>](#), [<Hn>](#), #0.0

```
if !HaveFP16Ext() then UNDEFINED;
```

```
integer d = UInt(Rd);
```

```
integer n = UInt(Rn);
```

```
integer esize = 16;
```

```
integer datasize = esize;
```

```
integer elements = 1;
```

```
CompareOp comparison = CompareOp\_LT;
```

### Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	1	0	1	1	1	1	0	1	sz	1	0	0	0	0	0	1	1	1	0	1	0	Rn						Rd					

FCMLT [<V><d>](#), [<V><n>](#), #0.0

```
integer d = UInt(Rd);
```

```
integer n = UInt(Rn);
```

```
integer esize = 32 << UInt(sz);
```

```
integer datasize = esize;
```

```
integer elements = 1;
```

```
CompareOp comparison = CompareOp\_LT;
```

### Vector half precision

(FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	Q	0	0	1	1	1	0	1	1	1	1	1	0	0	0	1	1	1	0	1	0	Rn						Rd					

FCMLT <Vd>.<T>, <Vn>.<T>, #0.0

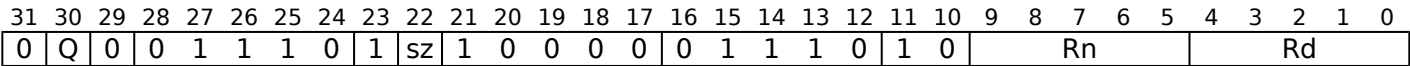
```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CompareOp comparison = CompareOp_LT;
```

Vector single-precision and double-precision



FCMLT <Vd>.<T>, <Vn>.<T>, #0.0

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CompareOp comparison = CompareOp_LT;
```

Assembler Symbols

<Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.

<Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.

<V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) zero = FPZero('0');
bits(esize) element;
boolean test_passed;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    case comparison of
        when CompareOp_GT test_passed = FPCompareGT(element, zero, FPCR[]);
        when CompareOp_GE test_passed = FPCompareGE(element, zero, FPCR[]);
        when CompareOp_EQ test_passed = FPCompareEQ(element, zero, FPCR[]);
        when CompareOp_LE test_passed = FPCompareGE(zero, element, FPCR[]);
        when CompareOp_LT test_passed = FPCompareGT(zero, element, FPCR[]);
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## FCMP

Floating-point quiet Compare (scalar). This instruction compares the two SIMD&FP source register values, or the first SIMD&FP source register value and zero. It writes the result to the *PSTATE*.{N, Z, C, V} flags.

This instruction raises an Invalid Operation floating-point exception if either or both of the operands is a signaling NaN.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1	1	1	1	0	f	t	y	p	e	1	Rm			0	0	1	0	0	0	Rn			0	x	0	0	0	
																												opc			

### Half-precision (ftype == 11 && opc == 00) (FEAT\_FP16)

FCMP <Hn>, <Hm>

### Half-precision, zero (ftype == 11 && Rm == (00000) && opc == 01) (FEAT\_FP16)

FCMP <Hn>, #0.0

### Single-precision (ftype == 00 && opc == 00)

FCMP <Sn>, <Sm>

### Single-precision, zero (ftype == 00 && Rm == (00000) && opc == 01)

FCMP <Sn>, #0.0

### Double-precision (ftype == 01 && opc == 00)

FCMP <Dn>, <Dm>

### Double-precision, zero (ftype == 01 && Rm == (00000) && opc == 01)

FCMP <Dn>, #0.0

```
integer n = UInt(Rn);
integer m = UInt(Rm);    // ignored when opc<0> == '1'

integer datasize;
case ftype of
  when '00' datasize = 32;
  when '01' datasize = 64;
  when '10' UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      datasize = 16;
    else
      UNDEFINED;

boolean signal_all_nans = (opc<1> == '1');
boolean cmp_with_zero = (opc<0> == '1');
```

## Assembler Symbols

<Dn>	For the double-precision variant: is the 64-bit name of the first SIMD&FP source register, encoded in the "Rn" field.  For the double-precision, zero variant: is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Dm>	Is the 64-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
<Hn>	For the half-precision variant: is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.  For the half-precision, zero variant: is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Hm>	Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
<Sn>	For the single-precision variant: is the 32-bit name of the first SIMD&FP source register, encoded in the "Rn" field.  For the single-precision, zero variant: is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Sm>	Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
bits(datasize) operand1 = V[n];  
bits(datasize) operand2;  
  
operand2 = if cmp_with_zero then FPZero('0') else V[m];  
  
PSTATE.<N,Z,C,V> = FPCompare(operand1, operand2, signal_all_nans, FPCR[]);
```

## Operational information

The IEEE 754 standard specifies that the result of a comparison is precisely one of <, ==, > or unordered. If either or both of the operands is a NaN, they are unordered, and all three of (Operand1 < Operand2), (Operand1 == Operand2) and (Operand1 > Operand2) are false. An unordered comparison sets the *PSTATE* condition flags to N=0, Z=0, C=1, and V=1.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## FCMPE

Floating-point signaling Compare (scalar). This instruction compares the two SIMD&FP source register values, or the first SIMD&FP source register value and zero. It writes the result to the *PSTATE*.{N, Z, C, V} flags.

This instruction raises an Invalid Operation floating-point exception if either or both of the operands is any type of NaN.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1	1	1	1	0	ftype		1	Rm				0	0	1	0	0	0	Rn				1	x	0	0	0	opc	

### Half-precision (ftype == 11 && opc == 10) (FEAT\_FP16)

FCMPE <Hn>, <Hm>

### Half-precision, zero (ftype == 11 && Rm == (00000) && opc == 11) (FEAT\_FP16)

FCMPE <Hn>, #0.0

### Single-precision (ftype == 00 && opc == 10)

FCMPE <Sn>, <Sm>

### Single-precision, zero (ftype == 00 && Rm == (00000) && opc == 11)

FCMPE <Sn>, #0.0

### Double-precision (ftype == 01 && opc == 10)

FCMPE <Dn>, <Dm>

### Double-precision, zero (ftype == 01 && Rm == (00000) && opc == 11)

FCMPE <Dn>, #0.0

```
integer n = UInt(Rn);
integer m = UInt(Rm);    // ignored when opc<0> == '1'

integer datasize;
case ftype of
    when '00' datasize = 32;
    when '01' datasize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            datasize = 16;
        else
            UNDEFINED;

boolean signal_all_nans = (opc<1> == '1');
boolean cmp_with_zero = (opc<0> == '1');
```

## Assembler Symbols

<Dn>	For the double-precision variant: is the 64-bit name of the first SIMD&FP source register, encoded in the "Rn" field.  For the double-precision, zero variant: is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Dm>	Is the 64-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
<Hn>	For the half-precision variant: is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.  For the half-precision, zero variant: is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Hm>	Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
<Sn>	For the single-precision variant: is the 32-bit name of the first SIMD&FP source register, encoded in the "Rn" field.  For the single-precision, zero variant: is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Sm>	Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
bits(datasize) operand1 = V[n];  
bits(datasize) operand2;  
  
operand2 = if cmp_with_zero then FPZero('0') else V[m];  
  
PSTATE.<N,Z,C,V> = FPCompare(operand1, operand2, signal_all_nans, FPCR[]);
```

## Operational information

The IEEE 754 standard specifies that the result of a comparison is precisely one of <, ==, > or unordered. If either or both of the operands is a NaN, they are unordered, and all three of (Operand1 < Operand2), (Operand1 == Operand2) and (Operand1 > Operand2) are false. An unordered comparison sets the *PSTATE* condition flags to N=0, Z=0, C=1, and V=1.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# FCSEL

Floating-point Conditional Select (scalar). This instruction allows the SIMD&FP destination register to take the value from either one or the other of two SIMD&FP source registers. If the condition passes, the first SIMD&FP source register value is taken, otherwise the second SIMD&FP source register value is taken.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1	1	1	1	0	ftype		1	Rm				cond				1	1	Rn				Rd						

## Half-precision (ftype == 11) (FEAT\_FP16)

FCSEL <Hd>, <Hn>, <Hm>, <cond>

## Single-precision (ftype == 00)

FCSEL <Sd>, <Sn>, <Sm>, <cond>

## Double-precision (ftype == 01)

FCSEL <Dd>, <Dn>, <Dm>, <cond>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer datasize;
case ftype of
    when '00' datasize = 32;
    when '01' datasize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            datasize = 16;
        else
            UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Dm> Is the 64-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Sm> Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <cond> Is one of the standard conditions, encoded in the "cond" field in the standard way.

## Operation

```
CheckFPAdvSIMDEnabled64();  
bits(datasize) result;  
  
result = if ConditionHolds(cond) then V[n] else V[m];  
  
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FCVT

Floating-point Convert precision (scalar). This instruction converts the floating-point value in the SIMD&FP source register to the precision for the destination register data type using the rounding mode that is determined by the [FPCR](#) and writes the result to the SIMD&FP destination register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1	1	1	1	0	ftype	1	0	0	0	1	opc	1	0	0	0	0												

**Half-precision to single-precision (ftype == 11 && opc == 00)**

FCVT <Sd>, <Hn>

**Half-precision to double-precision (ftype == 11 && opc == 01)**

FCVT <Dd>, <Hn>

**Single-precision to half-precision (ftype == 00 && opc == 11)**

FCVT <Hd>, <Sn>

**Single-precision to double-precision (ftype == 00 && opc == 01)**

FCVT <Dd>, <Sn>

**Double-precision to half-precision (ftype == 01 && opc == 11)**

FCVT <Hd>, <Dn>

**Double-precision to single-precision (ftype == 01 && opc == 00)**

FCVT <Sd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer srctype;
integer dstsize;

if ftype == opc then UNDEFINED;

case ftype of
  when '00' srctype = 32;
  when '01' srctype = 64;
  when '10' UNDEFINED;
  when '11' srctype = 16;
case opc of
  when '00' dstsize = 32;
  when '01' dstsize = 64;
  when '10' UNDEFINED;
  when '11' dstsize = 16;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();

bits(srcsize) operand = V[n];
FPCRTType fpcr = FPCR[];
boolean merge = IsMerging(fpcr);
bits(128) result = if merge then V[d] else Zeros();

Elem[result, 0, dstsize] = FPConvert(operand, fpcr);

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FCVTAS (vector)

Floating-point Convert to Signed integer, rounding to nearest with ties to Away (vector). This instruction converts each element in a vector from a floating-point value to a signed integer value using the Round to Nearest with Ties to Away rounding mode and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	1	1	1	1	0	0	1	1	1	0	0	1	0	Rn				Rd					
U																															

FCVTAS <Hd>, <Hn>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPRounding_TIEAWAY;
boolean unsigned = (U == '1');
```

## Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	sz	1	0	0	0	0	1	1	1	0	0	1	0	Rn					Rd				
U																															

FCVTAS <V><d>, <V><n>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPRounding_TIEAWAY;
boolean unsigned = (U == '1');
```

## Vector half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	1	1	1	1	0	0	1	1	1	0	0	1	0	Rn				Rd					
U																															

FCVTAS <Vd>.<T>, <Vn>.<T>

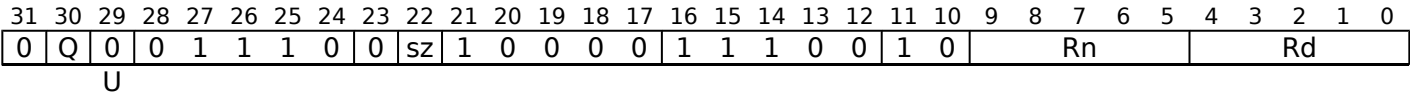
```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPRounding_TIEAWAY;
boolean unsigned = (U == '1');
```

Vector single-precision and double-precision



FCVTAS <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPRounding_TIEAWAY;
boolean unsigned = (U == '1');
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];

bits(esize) element;
FPCRType fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[d] else Zeros();

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPToFixed(element, 0, unsigned, fpcr, rounding);

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

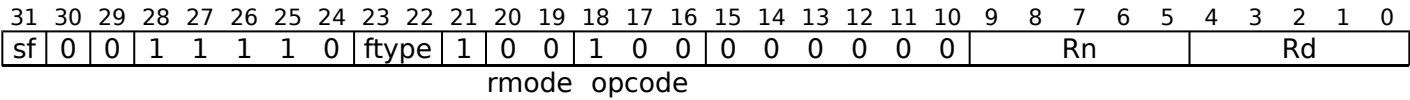
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FCVTAS (scalar)

Floating-point Convert to Signed integer, rounding to nearest with ties to Away (scalar). This instruction converts the floating-point value in the SIMD&FP source register to a 32-bit or 64-bit signed integer using the Round to Nearest with Ties to Away rounding mode, and writes the result to the general-purpose destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



**Half-precision to 32-bit (sf == 0 && ftype == 11)**  
(FEAT\_FP16)

```
FCVTAS <Wd>, <Hn>
```

**Half-precision to 64-bit (sf == 1 && ftype == 11)**  
(FEAT\_FP16)

```
FCVTAS <Xd>, <Hn>
```

**Single-precision to 32-bit (sf == 0 && ftype == 00)**

```
FCVTAS <Wd>, <Sn>
```

**Single-precision to 64-bit (sf == 1 && ftype == 00)**

```
FCVTAS <Xd>, <Sn>
```

**Double-precision to 32-bit (sf == 0 && ftype == 01)**

```
FCVTAS <Wd>, <Dn>
```

**Double-precision to 64-bit (sf == 1 && ftype == 01)**

```
FCVTAS <Xd>, <Dn>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;

case ftype of
  when '00'
    fltsize = 32;
  when '01'
    fltsize = 64;
  when '10'
    UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;
```



## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Hn>	Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Dn>	Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
FPCRTYPE fpcr = FPCR[];  
bits(fltsize) fltval;  
bits(intsize) intval;  
  
fltval = V[n];  
intval = FPToFixed(fltval, 0, FALSE, fpcr, FPRounding_TIEAWAY);  
X[d] = intval;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FCVTAU (vector)

Floating-point Convert to Unsigned integer, rounding to nearest with ties to Away (vector). This instruction converts each element in a vector from a floating-point value to an unsigned integer value using the Round to Nearest with Ties to Away rounding mode and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0						
0	1	1	1	1	1	1	0	0	1	1	1	1	0	0	1	1	1	0	0	1	0	Rn				Rd											
U																																					

FCVTAU <Hd>, <Hn>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPRounding_TIEAWAY;
boolean unsigned = (U == '1');
```

## Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	0	sz	1	0	0	0	0	1	1	1	0	0	1	0	Rn				Rd					
U																															

FCVTAU <V><d>, <V><n>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPRounding_TIEAWAY;
boolean unsigned = (U == '1');
```

## Vector half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	1	1	1	1	0	0	1	1	1	0	0	1	0	Rn				Rd					
U																															

FCVTAU <Vd>.<T>, <Vn>.<T>

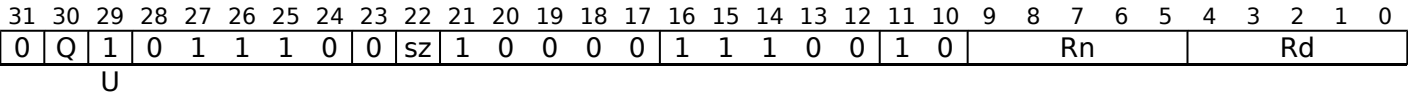
```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPRounding_TIEAWAY;
boolean unsigned = (U == '1');
```

Vector single-precision and double-precision



FCVTAU <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPRounding_TIEAWAY;
boolean unsigned = (U == '1');
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.

<V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];

bits(esize) element;
FPCRTYPE fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[d] else Zeros();

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPToFixed(element, 0, unsigned, fpcr, rounding);

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

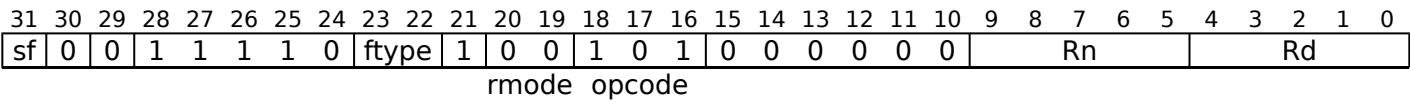
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FCVTAU (scalar)

Floating-point Convert to Unsigned integer, rounding to nearest with ties to Away (scalar). This instruction converts the floating-point value in the SIMD&FP source register to a 32-bit or 64-bit unsigned integer using the Round to Nearest with Ties to Away rounding mode, and writes the result to the general-purpose destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



**Half-precision to 32-bit (sf == 0 && ftype == 11)**  
(FEAT\_FP16)

FCVTAU <Wd>, <Hn>

**Half-precision to 64-bit (sf == 1 && ftype == 11)**  
(FEAT\_FP16)

FCVTAU <Xd>, <Hn>

**Single-precision to 32-bit (sf == 0 && ftype == 00)**

FCVTAU <Wd>, <Sn>

**Single-precision to 64-bit (sf == 1 && ftype == 00)**

FCVTAU <Xd>, <Sn>

**Double-precision to 32-bit (sf == 0 && ftype == 01)**

FCVTAU <Wd>, <Dn>

**Double-precision to 64-bit (sf == 1 && ftype == 01)**

FCVTAU <Xd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;

case ftype of
  when '00'
    fltsize = 32;
  when '01'
    fltsize = 64;
  when '10'
    UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;
```

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Hn>	Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Dn>	Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
FPCRTYPE fpcr = FPCR[];  
bits(fltsize) fltval;  
bits(intsize) intval;  
  
fltval = V[n];  
intval = FPToFixed(fltval, 0, TRUE, fpcr, FPRounding_TIEAWAY);  
X[d] = intval;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FCVTL, FCVTL2

Floating-point Convert to higher precision Long (vector). This instruction reads each element in a vector in the SIMD&FP source register, converts each value to double the precision of the source element using the rounding mode that is determined by the *FPCR*, and writes each result to the equivalent element of the vector in the SIMD&FP destination register.

Where the operation lengthens a 64-bit vector to a 128-bit vector, the FCVTL2 variant operates on the elements in the top 64 bits of the source register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	sz	1	0	0	0	0	1	0	1	1	1	1	0	Rn					Rd				

FCVTL{2} <Vd>.<Ta>, <Vn>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16 << UInt(sz);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in "Q":

Q 2	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in "sz":

sz	<Ta>
0	4S
1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in "sz:Q":

sz	Q	<Tb>
0	0	4H
0	1	8H
1	0	2S
1	1	4S

## Operation

```
CheckFPAdvSIMDEnabled64();  
bits(datasize) operand = Vpart[n, part];  
bits(2*datasize) result;  
  
for e = 0 to elements-1  
    Elem[result, e, 2*esize] = FPConvert(Elem[operand, e, esize], FPCR[]);  
  
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# FCVTMS (vector)

Floating-point Convert to Signed integer, rounding toward Minus infinity (vector). This instruction converts a scalar or each element in a vector from a floating-point value to a signed integer value using the Round towards Minus Infinity rounding mode, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	1	1	1	1	0	0	1	1	0	1	1	1	0	Rn				Rd					
U								o2				o1																			

FCVTMS <Hd>, <Hn>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

## Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	sz	1	0	0	0	0	1	1	0	1	1	1	0	Rn				Rd					
U								o2				o1																			

FCVTMS <V><d>, <V><n>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

## Vector half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	1	1	1	1	0	0	1	1	0	1	1	1	0	Rn				Rd					
U								o2				o1																			

FCVTMS <Vd>.<T>, <Vn>.<T>

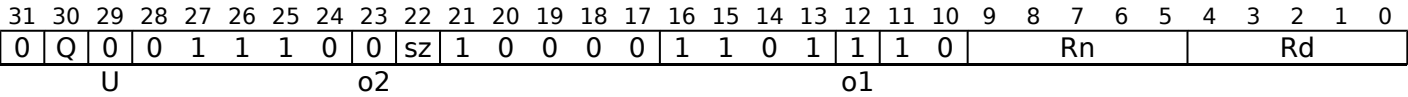
```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

Vector single-precision and double-precision



FCVTMS <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];

bits(esize) element;
FPCRType fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[d] else Zeros();

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPToFixed(element, 0, unsigned, fpcr, rounding);

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

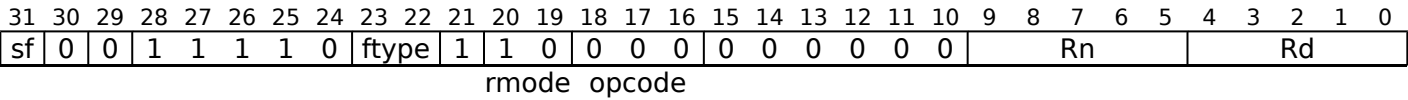
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FCVTMS (scalar)

Floating-point Convert to Signed integer, rounding toward Minus infinity (scalar). This instruction converts the floating-point value in the SIMD&FP source register to a 32-bit or 64-bit signed integer using the Round towards Minus Infinity rounding mode, and writes the result to the general-purpose destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



**Half-precision to 32-bit (sf == 0 && ftype == 11)**  
(FEAT\_FP16)

FCVTMS <Wd>, <Hn>

**Half-precision to 64-bit (sf == 1 && ftype == 11)**  
(FEAT\_FP16)

FCVTMS <Xd>, <Hn>

**Single-precision to 32-bit (sf == 0 && ftype == 00)**

FCVTMS <Wd>, <Sn>

**Single-precision to 64-bit (sf == 1 && ftype == 00)**

FCVTMS <Xd>, <Sn>

**Double-precision to 32-bit (sf == 0 && ftype == 01)**

FCVTMS <Wd>, <Dn>

**Double-precision to 64-bit (sf == 1 && ftype == 01)**

FCVTMS <Xd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;
FPRounding rounding;

case ftype of
  when '00'
    fltsize = 32;
  when '01'
    fltsize = 64;
  when '10'
    UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;

rounding = FPDecodeRounding(rmode);
```

**Assembler Symbols**

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Hn>	Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Dn>	Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
FPCRType fpcr = FPCR[];  
bits(fltsize) fltval;  
bits(intsize) intval;  
  
fltval = V[n];  
intval = FPToFixed(fltval, 0, FALSE, fpcr, rounding);  
X[d] = intval;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FCVTMU (vector)

Floating-point Convert to Unsigned integer, rounding toward Minus infinity (vector). This instruction converts a scalar or each element in a vector from a floating-point value to an unsigned integer value using the Round towards Minus Infinity rounding mode, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	0	1	1	1	1	0	0	1	1	0	1	1	1	0	Rn				Rd					
U								o2				o1																			

FCVTMU <Hd>, <Hn>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

## Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	0	sz	1	0	0	0	0	1	1	0	1	1	1	0	Rn				Rd					
U								o2				o1																			

FCVTMU <V><d>, <V><n>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

## Vector half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	1	1	1	1	0	0	1	1	0	1	1	1	0	Rn				Rd					
U								o2				o1																			

FCVTMU <Vd>.<T>, <Vn>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

## Vector single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	sz	1	0	0	0	0	1	1	0	1	1	1	0	Rn				Rd					
U								o2				o1																			

FCVTMU <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

## Assembler Symbols

<Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.

<Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.

<V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.



## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];

bits(esize) element;
FPCRType fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[d] else Zeros();

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPToFixed(element, 0, unsigned, fpcr, rounding);

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

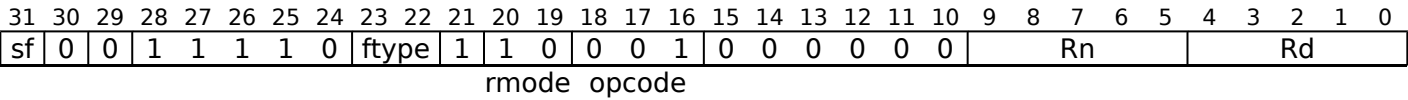
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FCVTMU (scalar)

Floating-point Convert to Unsigned integer, rounding toward Minus infinity (scalar). This instruction converts the floating-point value in the SIMD&FP source register to a 32-bit or 64-bit unsigned integer using the Round towards Minus Infinity rounding mode, and writes the result to the general-purpose destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



**Half-precision to 32-bit (sf == 0 && ftype == 11)**  
(FEAT\_FP16)

FCVTMU <Wd>, <Hn>

**Half-precision to 64-bit (sf == 1 && ftype == 11)**  
(FEAT\_FP16)

FCVTMU <Xd>, <Hn>

**Single-precision to 32-bit (sf == 0 && ftype == 00)**

FCVTMU <Wd>, <Sn>

**Single-precision to 64-bit (sf == 1 && ftype == 00)**

FCVTMU <Xd>, <Sn>

**Double-precision to 32-bit (sf == 0 && ftype == 01)**

FCVTMU <Wd>, <Dn>

**Double-precision to 64-bit (sf == 1 && ftype == 01)**

FCVTMU <Xd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;
FPRounding rounding;

case ftype of
  when '00'
    fltsize = 32;
  when '01'
    fltsize = 64;
  when '10'
    UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;

rounding = FPDecodeRounding(rmode);
```

**Assembler Symbols**

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Hn>	Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Dn>	Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
FPCRType fpcr = FPCR[];  
bits(fltsize) fltval;  
bits(intsize) intval;  
  
fltval = V[n];  
intval = FPToFixed(fltval, 0, TRUE, fpcr, rounding);  
X[d] = intval;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FCVTN, FCVTN2

Floating-point Convert to lower precision Narrow (vector). This instruction reads each vector element in the SIMD&FP source register, converts each result to half the precision of the source element, writes the final result to a vector, and writes the vector to the lower or upper half of the destination SIMD&FP register. The destination vector elements are half as long as the source vector elements. The rounding mode is determined by the *FPCR*.

The FCVTN instruction writes the vector to the lower half of the destination register and clears the upper half, while the FCVTN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	sz	1	0	0	0	0	1	0	1	1	0	1	0	Rn				Rd					

FCVTN{2} <Vd>.<Tb>, <Vn>.<Ta>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16 << UInt(sz);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Tb> Is an arrangement specifier, encoded in “sz:Q”:

sz	Q	<Tb>
0	0	4H
0	1	8H
1	0	2S
1	1	4S

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<Ta> Is an arrangement specifier, encoded in “sz”:

sz	<Ta>
0	4S
1	2D

## Operation

```
CheckFPAdvSIMDEnabled64();  
bits(2*datasize) operand = V[n];  
bits(datasize) result;  
  
for e = 0 to elements-1  
    Elem[result, e, esize] = FPConvert(Elem[operand, e, 2*esize], FPCR[]);  
Vpart[d, part] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FCVTNS (vector)

Floating-point Convert to Signed integer, rounding to nearest with ties to even (vector). This instruction converts a scalar or each element in a vector from a floating-point value to a signed integer value using the Round to Nearest rounding mode, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	1	1	1	1	0	0	1	1	0	1	0	1	0	Rn				Rd					
U								o2				o1																			

FCVTNS <Hd>, <Hn>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

## Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	sz	1	0	0	0	0	1	1	0	1	0	1	0	Rn				Rd					
U								o2				o1																			

FCVTNS <V><d>, <V><n>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

## Vector half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	1	1	1	1	0	0	1	1	0	1	0	1	0	Rn				Rd					
U								o2				o1																			

FCVTNS <Vd>.<T>, <Vn>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

## Vector single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	sz	1	0	0	0	0	1	1	0	1	0	1	0	Rn				Rd					
U								o2				o1																			

FCVTNS <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

## Assembler Symbols

<Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.

<Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.

<V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.



## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];

bits(esize) element;
FPCRType fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[d] else Zeros();

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPToFixed(element, 0, unsigned, fpcr, rounding);

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

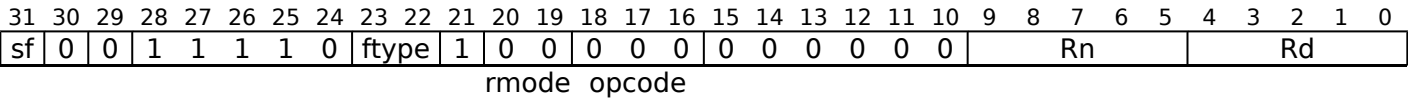
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FCVTNS (scalar)

Floating-point Convert to Signed integer, rounding to nearest with ties to even (scalar). This instruction converts the floating-point value in the SIMD&FP source register to a 32-bit or 64-bit signed integer using the Round to Nearest rounding mode, and writes the result to the general-purpose destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



**Half-precision to 32-bit (sf == 0 && ftype == 11)**  
(FEAT\_FP16)

FCVTNS <Wd>, <Hn>

**Half-precision to 64-bit (sf == 1 && ftype == 11)**  
(FEAT\_FP16)

FCVTNS <Xd>, <Hn>

**Single-precision to 32-bit (sf == 0 && ftype == 00)**

FCVTNS <Wd>, <Sn>

**Single-precision to 64-bit (sf == 1 && ftype == 00)**

FCVTNS <Xd>, <Sn>

**Double-precision to 32-bit (sf == 0 && ftype == 01)**

FCVTNS <Wd>, <Dn>

**Double-precision to 64-bit (sf == 1 && ftype == 01)**

FCVTNS <Xd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;
FPRounding rounding;

case ftype of
  when '00'
    fltsize = 32;
  when '01'
    fltsize = 64;
  when '10'
    UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;

rounding = FPDecodeRounding(rmode);
```

**Assembler Symbols**

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Hn>	Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Dn>	Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
FPCRTYPE fpcr = FPCR[];  
bits(fltsize) fltval;  
bits(intsize) intval;  
  
fltval = V[n];  
intval = FPToFixed(fltval, 0, FALSE, fpcr, rounding);  
X[d] = intval;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FCVTNU (vector)

Floating-point Convert to Unsigned integer, rounding to nearest with ties to even (vector). This instruction converts a scalar or each element in a vector from a floating-point value to an unsigned integer value using the Round to Nearest rounding mode, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	0	1	1	1	1	0	0	1	1	0	1	0	1	0	Rn				Rd					
U								o2				o1																			

FCVTNU <Hd>, <Hn>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

## Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	0	sz	1	0	0	0	0	1	1	0	1	0	1	0	Rn				Rd					
U								o2				o1																			

FCVTNU <V><d>, <V><n>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

## Vector half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	1	1	1	1	0	0	1	1	0	1	0	1	0	Rn				Rd					
U								o2				o1																			

FCVTNU <Vd>.<T>, <Vn>.<T>

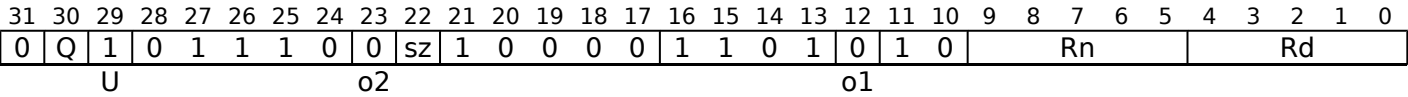
```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

Vector single-precision and double-precision



FCVTNU <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];

bits(esize) element;
FPCRType fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[d] else Zeros();

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPToFixed(element, 0, unsigned, fpcr, rounding);

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

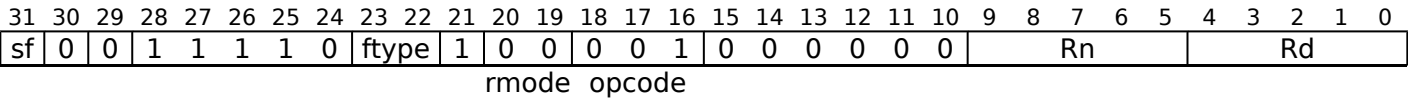
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FCVTNU (scalar)

Floating-point Convert to Unsigned integer, rounding to nearest with ties to even (scalar). This instruction converts the floating-point value in the SIMD&FP source register to a 32-bit or 64-bit unsigned integer using the Round to Nearest rounding mode, and writes the result to the general-purpose destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.





**Half-precision to 32-bit (sf == 0 && ftype == 11)**  
(FEAT\_FP16)

FCVTNU <Wd>, <Hn>

**Half-precision to 64-bit (sf == 1 && ftype == 11)**  
(FEAT\_FP16)

FCVTNU <Xd>, <Hn>

**Single-precision to 32-bit (sf == 0 && ftype == 00)**

FCVTNU <Wd>, <Sn>

**Single-precision to 64-bit (sf == 1 && ftype == 00)**

FCVTNU <Xd>, <Sn>

**Double-precision to 32-bit (sf == 0 && ftype == 01)**

FCVTNU <Wd>, <Dn>

**Double-precision to 64-bit (sf == 1 && ftype == 01)**

FCVTNU <Xd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;
FPRounding rounding;

case ftype of
  when '00'
    fltsize = 32;
  when '01'
    fltsize = 64;
  when '10'
    UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;

rounding = FPDecodeRounding(rmode);
```

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Hn>	Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Dn>	Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
FPCRType fpcr = FPCR[];  
bits(fltsize) fltval;  
bits(intsize) intval;  
  
fltval = V[n];  
intval = FPToFixed(fltval, 0, TRUE, fpcr, rounding);  
X[d] = intval;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FCVTPS (vector)

Floating-point Convert to Signed integer, rounding toward Plus infinity (vector). This instruction converts a scalar or each element in a vector from a floating-point value to a signed integer value using the Round towards Plus Infinity rounding mode, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	1	1	1	1	1	0	0	1	1	0	1	0	1	0	Rn				Rd					
U				o2				o1																							

FCVTPS <Hd>, <Hn>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

## Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	1	sz	1	0	0	0	0	1	1	0	1	0	1	0	Rn				Rd					
U				o2				o1																							

FCVTPS <V><d>, <V><n>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

## Vector half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	1	1	1	1	0	0	1	1	0	1	0	1	0	Rn				Rd					
U				o2				o1																							

FCVTPS <Vd>.<T>, <Vn>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

## Vector single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	sz	1	0	0	0	0	1	1	0	1	0	1	0	Rn				Rd					
U								o2				o1																			

FCVTPS <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

## Assembler Symbols

<Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.

<Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.

<V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];

bits(esize) element;
FPCRType fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[d] else Zeros();

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPToFixed(element, 0, unsigned, fpcr, rounding);

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

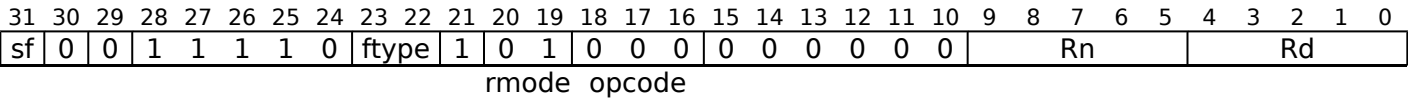
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FCVTPS (scalar)

Floating-point Convert to Signed integer, rounding toward Plus infinity (scalar). This instruction converts the floating-point value in the SIMD&FP source register to a 32-bit or 64-bit signed integer using the Round towards Plus Infinity rounding mode, and writes the result to the general-purpose destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



**Half-precision to 32-bit (sf == 0 && ftype == 11)**  
(FEAT\_FP16)

FCVTPS <Wd>, <Hn>

**Half-precision to 64-bit (sf == 1 && ftype == 11)**  
(FEAT\_FP16)

FCVTPS <Xd>, <Hn>

**Single-precision to 32-bit (sf == 0 && ftype == 00)**

FCVTPS <Wd>, <Sn>

**Single-precision to 64-bit (sf == 1 && ftype == 00)**

FCVTPS <Xd>, <Sn>

**Double-precision to 32-bit (sf == 0 && ftype == 01)**

FCVTPS <Wd>, <Dn>

**Double-precision to 64-bit (sf == 1 && ftype == 01)**

FCVTPS <Xd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;
FPRounding rounding;

case ftype of
  when '00'
    fltsize = 32;
  when '01'
    fltsize = 64;
  when '10'
    UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;

rounding = FPDecodeRounding(rmode);
```

**Assembler Symbols**

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Hn>	Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Dn>	Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
FPCRTYPE fpcr = FPCR[];  
bits(fltsize) fltval;  
bits(intsize) intval;  
  
fltval = V[n];  
intval = FPToFixed(fltval, 0, FALSE, fpcr, rounding);  
X[d] = intval;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# FCVTPU (vector)

Floating-point Convert to Unsigned integer, rounding toward Plus infinity (vector). This instruction converts a scalar or each element in a vector from a floating-point value to an unsigned integer value using the Round towards Plus Infinity rounding mode, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	1	1	1	1	1	0	0	1	1	0	1	0	1	0	Rn				Rd					
U								o2				o1																			

FCVTPU <Hd>, <Hn>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

## Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	1	sz	1	0	0	0	0	1	1	0	1	0	1	0	Rn				Rd					
U								o2				o1																			

FCVTPU <V><d>, <V><n>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

## Vector half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	Q	1	0	1	1	1	0	1	1	1	1	0	0	1	1	0	1	0	1	0	Rn						Rd					
U								o2				o1																				

FCVTPU <Vd>.<T>, <Vn>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

## Vector single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	sz	1	0	0	0	0	1	1	0	1	0	1	0	Rn				Rd					
U								o2				o1																			

FCVTPU <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

## Assembler Symbols

<Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.

<Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.

<V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];

bits(esize) element;
FPCRTYPE fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[d] else Zeros();

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPToFixed(element, 0, unsigned, fpcr, rounding);

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

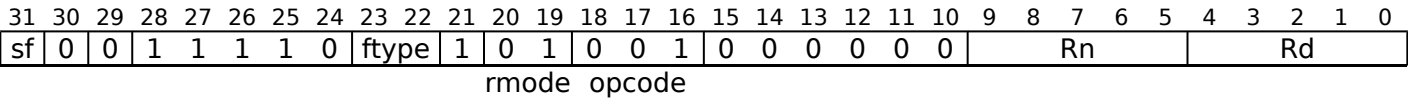
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FCVTPU (scalar)

Floating-point Convert to Unsigned integer, rounding toward Plus infinity (scalar). This instruction converts the floating-point value in the SIMD&FP source register to a 32-bit or 64-bit unsigned integer using the Round towards Plus Infinity rounding mode, and writes the result to the general-purpose destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



**Half-precision to 32-bit (sf == 0 && ftype == 11)**  
(FEAT\_FP16)

FCVTPU <Wd>, <Hn>

**Half-precision to 64-bit (sf == 1 && ftype == 11)**  
(FEAT\_FP16)

FCVTPU <Xd>, <Hn>

**Single-precision to 32-bit (sf == 0 && ftype == 00)**

FCVTPU <Wd>, <Sn>

**Single-precision to 64-bit (sf == 1 && ftype == 00)**

FCVTPU <Xd>, <Sn>

**Double-precision to 32-bit (sf == 0 && ftype == 01)**

FCVTPU <Wd>, <Dn>

**Double-precision to 64-bit (sf == 1 && ftype == 01)**

FCVTPU <Xd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;
FPRounding rounding;

case ftype of
  when '00'
    fltsize = 32;
  when '01'
    fltsize = 64;
  when '10'
    UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;

rounding = FPDecodeRounding(rmode);
```

**Assembler Symbols**

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Hn>	Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Dn>	Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
FPCRTYPE fpcr = FPCR[];  
bits(fltsize) fltval;  
bits(intsize) intval;  
  
fltval = V[n];  
intval = FPToFixed(fltval, 0, TRUE, fpcr, rounding);  
X[d] = intval;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FCVTXN, FCVTXN2

Floating-point Convert to lower precision Narrow, rounding to odd (vector). This instruction reads each vector element in the source SIMD&FP register, narrows each value to half the precision of the source element using the Round to Odd rounding mode, writes the result to a vector, and writes the vector to the destination SIMD&FP register.

This instruction uses the Round to Odd rounding mode which is not defined by the IEEE 754-2008 standard. This rounding mode ensures that if the result of the conversion is inexact the least significant bit of the mantissa is forced to 1. This rounding mode enables a floating-point value to be converted to a lower precision format via an intermediate precision format while avoiding double rounding errors. For example, a 64-bit floating-point value can be converted to a correctly rounded 16-bit floating-point value by first using this instruction to produce a 32-bit value and then using another instruction with the wanted rounding mode to convert the 32-bit value to the final 16-bit floating-point value.

The FCVTXN instruction writes the vector to the lower half of the destination register and clears the upper half, while the FCVTXN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.

This instruction can generate a floating-point exception. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#) or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	0	sz	1	0	0	0	0	1	0	1	1	0	1	0	Rn				Rd					

FCVTXN [<Vb><d>](#), [<Va><n>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz == '0' then UNDEFINED;
integer esize = 32;
integer datasize = esize;
integer elements = 1;
integer part = 0;
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	sz	1	0	0	0	0	1	0	1	1	0	1	0	Rn				Rd					

FCVTXN{2} [<Vd>.<Tb>](#), [<Vn>.<Ta>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz == '0' then UNDEFINED;
integer esize = 32;
integer datasize = 64;
integer elements = 2;
integer part = UInt(Q);
```

## Assembler Symbols

- 2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Tb> Is an arrangement specifier, encoded in "sz:Q":

sz	Q	<Tb>
0	x	RESERVED
1	0	2S
1	1	4S

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<Ta> Is an arrangement specifier, encoded in "sz":

sz	<Ta>
0	RESERVED
1	2D

<Vb> Is the destination width specifier, encoded in "sz":

sz	<Vb>
0	RESERVED
1	S

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Va> Is the source width specifier, encoded in "sz":

sz	<Va>
0	RESERVED
1	D

<n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
```

```
bits(2*datasize) operand = V[n];
```

```
FPCRTType fpcr = FPCR[];
```

```
boolean merge = elements == 1 && IsMerging(fpcr);
```

```
bits(128) result = if merge then V[d] else Zeros();
```

```
for e = 0 to elements-1
```

```
    Elem[result, e, esize] = FPConvert(Elem[operand, e, 2*esize], fpcr, FPRounding_ODD);
```

```
if merge then
```

```
    V[d] = result;
```

```
else
```

```
    Vpart[d, part] = Elem[result, 0, datasize];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



## FCVTZS (vector, fixed-point)

Floating-point Convert to Signed fixed-point, rounding toward Zero (vector). This instruction converts a scalar or each element in a vector from floating-point to fixed-point signed integer using the Round towards Zero rounding mode, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	0	!= 0000				immb			1	1	1	1	1	1	Rn			Rd						
U									immh																						

**FCVTZS** [<V><d>](#), [<V><n>](#), [#<fbits>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '000x' || (immh == '001x' && !HaveFP16Ext()) then UNDEFINED;
integer esize = if immh == '1xxx' then 64 else if immh == '01xx' then 32 else 16;
integer datasize = esize;
integer elements = 1;

integer fracbits = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
FPRounding rounding = FPRounding_ZERO;
```

### Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	0	!= 0000				immb			1	1	1	1	1	1	Rn			Rd						
U									immb																						

**FCVTZS** [<Vd>.<T>](#), [<Vn>.<T>](#), [#<fbits>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh == '000x' || (immh == '001x' && !HaveFP16Ext()) then UNDEFINED;
if immh<3>:Q == '10' then UNDEFINED;
integer esize = if immh == '1xxx' then 64 else if immh == '01xx' then 32 else 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer fracbits = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
FPRounding rounding = FPRounding_ZERO;
```

### Assembler Symbols

[<V>](#) Is a width specifier, encoded in “immh”:

immh	<V>
000x	RESERVED
001x	H
01xx	S
1xxx	D

<d> Is the number of the SIMD&FP destination register, in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	x	RESERVED
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<fbits> For the scalar variant: is the number of fractional bits, in the range 1 to the operand width, encoded in "immh:immb":

immh	<fbits>
000x	RESERVED
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

For the vector variant: is the number of fractional bits, in the range 1 to the element width, encoded in "immh:immb":

immh	<fbits>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	RESERVED
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];

bits(esize) element;
FPCRTType fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[d] else Zeros();
for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPToFixed(element, fracbits, unsigned, fpcr, rounding);

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## FCVTZS (vector, integer)

Floating-point Convert to Signed integer, rounding toward Zero (vector). This instruction converts a scalar or each element in a vector from a floating-point value to a signed integer value using the Round towards Zero rounding mode, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

### Scalar half precision

(FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	1	1	1	1	1	0	0	1	1	0	1	1	1	0	Rn				Rd					
U				o2				o1																							

FCVTZS <Hd>, <Hn>

```
if !HaveFP16Ext() then UNDEFINED;
```

```
integer d = UInt(Rd);
```

```
integer n = UInt(Rn);
```

```
integer esize = 16;
```

```
integer datasize = esize;
```

```
integer elements = 1;
```

```
FPRounding rounding = FPDecodeRounding(o1:o2);
```

```
boolean unsigned = (U == '1');
```

### Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	1	sz	1	0	0	0	0	1	1	0	1	1	1	0	Rn				Rd					
U				o2				o1																							

FCVTZS <V><d>, <V><n>

```
integer d = UInt(Rd);
```

```
integer n = UInt(Rn);
```

```
integer esize = 32 << UInt(sz);
```

```
integer datasize = esize;
```

```
integer elements = 1;
```

```
FPRounding rounding = FPDecodeRounding(o1:o2);
```

```
boolean unsigned = (U == '1');
```

### Vector half precision

(FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	1	1	1	1	0	0	1	1	0	1	1	1	0	Rn				Rd					
U				o2				o1																							

FCVTZS <Vd>.<T>, <Vn>.<T>

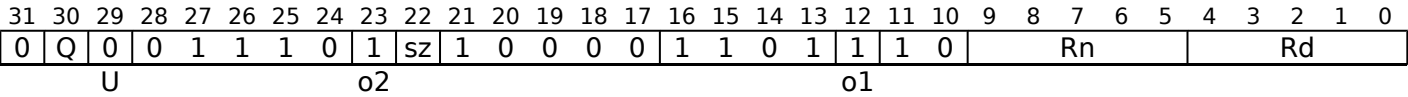
```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

Vector single-precision and double-precision



FCVTZS <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];

bits(esize) element;
FPCRTYPE fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[d] else Zeros();

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPToFixed(element, 0, unsigned, fpcr, rounding);

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

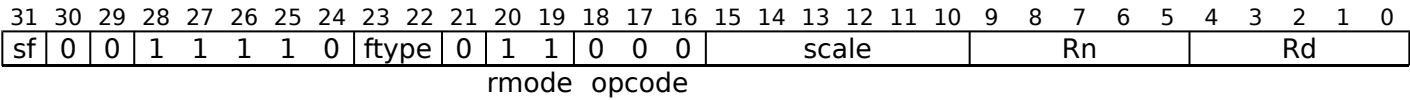
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FCVTZS (scalar, fixed-point)

Floating-point Convert to Signed fixed-point, rounding toward Zero (scalar). This instruction converts the floating-point value in the SIMD&FP source register to a 32-bit or 64-bit fixed-point signed integer using the Round towards Zero rounding mode, and writes the result to the general-purpose destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.



Half-precision to 32-bit (sf == 0 && ftype == 11)  
(FEAT\_FP16)

```
FCVTZS <Wd>, <Hn>, #<fbits>
```

Half-precision to 64-bit (sf == 1 && ftype == 11)  
(FEAT\_FP16)

```
FCVTZS <Xd>, <Hn>, #<fbits>
```

Single-precision to 32-bit (sf == 0 && ftype == 00)

```
FCVTZS <Wd>, <Sn>, #<fbits>
```

Single-precision to 64-bit (sf == 1 && ftype == 00)

```
FCVTZS <Xd>, <Sn>, #<fbits>
```

Double-precision to 32-bit (sf == 0 && ftype == 01)

```
FCVTZS <Wd>, <Dn>, #<fbits>
```

Double-precision to 64-bit (sf == 1 && ftype == 01)

```
FCVTZS <Xd>, <Dn>, #<fbits>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;

case ftype of
    when '00' fltsize = 32;
    when '01' fltsize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            fltsize = 16;
        else
            UNDEFINED;

if sf == '0' && scale<5> == '0' then UNDEFINED;
integer fracbits = 64 - UInt(scale);
```

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Hn>	Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Dn>	Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<fbits>	For the double-precision to 32-bit, half-precision to 32-bit and single-precision to 32-bit variant: is the number of bits after the binary point in the fixed-point destination, in the range 1 to 32, encoded as 64 minus "scale".  For the double-precision to 64-bit, half-precision to 64-bit and single-precision to 64-bit variant: is the number of bits after the binary point in the fixed-point destination, in the range 1 to 64, encoded as 64 minus "scale".

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
FPCRTType fpcr = FPCR[];  
bits(fltsize) fltval;  
bits(intsize) intval;  
  
fltval = V[n];  
intval = FPToFixed(fltval, fracbits, FALSE, fpcr, FPRounding_ZERO);  
X[d] = intval;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

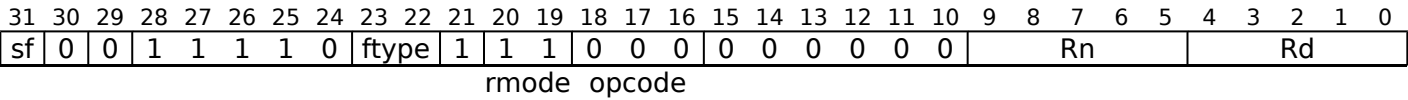
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FCVTZS (scalar, integer)

Floating-point Convert to Signed integer, rounding toward Zero (scalar). This instruction converts the floating-point value in the SIMD&FP source register to a 32-bit or 64-bit signed integer using the Round towards Zero rounding mode, and writes the result to the general-purpose destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.





**Half-precision to 32-bit (sf == 0 && ftype == 11)**  
(FEAT\_FP16)

FCVTZS <Wd>, <Hn>

**Half-precision to 64-bit (sf == 1 && ftype == 11)**  
(FEAT\_FP16)

FCVTZS <Xd>, <Hn>

**Single-precision to 32-bit (sf == 0 && ftype == 00)**

FCVTZS <Wd>, <Sn>

**Single-precision to 64-bit (sf == 1 && ftype == 00)**

FCVTZS <Xd>, <Sn>

**Double-precision to 32-bit (sf == 0 && ftype == 01)**

FCVTZS <Wd>, <Dn>

**Double-precision to 64-bit (sf == 1 && ftype == 01)**

FCVTZS <Xd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;
FPRounding rounding;

case ftype of
  when '00'
    fltsize = 32;
  when '01'
    fltsize = 64;
  when '10'
    UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;

rounding = FPDecodeRounding(rmode);
```

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Hn>	Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Dn>	Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
FPCRTYPE fpcr = FPCR[];  
bits(fltsize) fltval;  
bits(intsize) intval;  
  
fltval = V[n];  
intval = FPToFixed(fltval, 0, FALSE, fpcr, rounding);  
X[d] = intval;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## FCVTZU (vector, fixed-point)

Floating-point Convert to Unsigned fixed-point, rounding toward Zero (vector). This instruction converts a scalar or each element in a vector from floating-point to fixed-point unsigned integer using the Round towards Zero rounding mode, and writes the result to the general-purpose destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	1	0	!= 0000				immb			1	1	1	1	1	1	Rn				Rd					
U									immh																						

FCVTZU <V><d>, <V><n>, #<fbits>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '000x' || (immh == '001x' && !HaveFP16Ext()) then UNDEFINED;
integer esize = if immh == '1xxx' then 64 else if immh == '01xx' then 32 else 16;
integer datasize = esize;
integer elements = 1;

integer fracbits = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
FPRounding rounding = FPRounding_ZERO;
```

### Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	0	!= 0000				immb			1	1	1	1	1	1	Rn			Rd						
U									immb																						

FCVTZU <Vd>.<T>, <Vn>.<T>, #<fbits>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh == '000x' || (immh == '001x' && !HaveFP16Ext()) then UNDEFINED;
if immh<3>:Q == '10' then UNDEFINED;
integer esize = if immh == '1xxx' then 64 else if immh == '01xx' then 32 else 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer fracbits = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
FPRounding rounding = FPRounding_ZERO;
```

### Assembler Symbols

<V>            Is a width specifier, encoded in “immh”:

immh	<V>
000x	RESERVED
001x	H
01xx	S
1xxx	D

<d> Is the number of the SIMD&FP destination register, in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	x	RESERVED
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<fbits> For the scalar variant: is the number of fractional bits, in the range 1 to the operand width, encoded in "immh:immb":

immh	<fbits>
000x	RESERVED
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

For the vector variant: is the number of fractional bits, in the range 1 to the element width, encoded in "immh:immb":

immh	<fbits>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	RESERVED
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];

bits(esize) element;
FPCRTType fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[d] else Zeros();
for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPToFixed(element, fracbits, unsigned, fpcr, rounding);

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## FCVTZU (vector, integer)

Floating-point Convert to Unsigned integer, rounding toward Zero (vector). This instruction converts a scalar or each element in a vector from a floating-point value to an unsigned integer value using the Round towards Zero rounding mode, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

### Scalar half precision

(FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	1	1	1	1	1	0	0	1	1	0	1	1	1	0	Rn				Rd					
U								o2				o1																			

FCVTZU <Hd>, <Hn>

```
if !HaveFP16Ext() then UNDEFINED;
```

```
integer d = UInt(Rd);
```

```
integer n = UInt(Rn);
```

```
integer esize = 16;
```

```
integer datasize = esize;
```

```
integer elements = 1;
```

```
FPRounding rounding = FPDecodeRounding(o1:o2);
```

```
boolean unsigned = (U == '1');
```

### Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	1	sz	1	0	0	0	0	1	1	0	1	1	1	0	Rn				Rd					
U								o2				o1																			

FCVTZU <V><d>, <V><n>

```
integer d = UInt(Rd);
```

```
integer n = UInt(Rn);
```

```
integer esize = 32 << UInt(sz);
```

```
integer datasize = esize;
```

```
integer elements = 1;
```

```
FPRounding rounding = FPDecodeRounding(o1:o2);
```

```
boolean unsigned = (U == '1');
```

### Vector half precision

(FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	1	1	1	0	0	1	1	0	1	1	1	0	Rn				Rd						
U								o2				o1																			

FCVTZU <Vd>.<T>, <Vn>.<T>

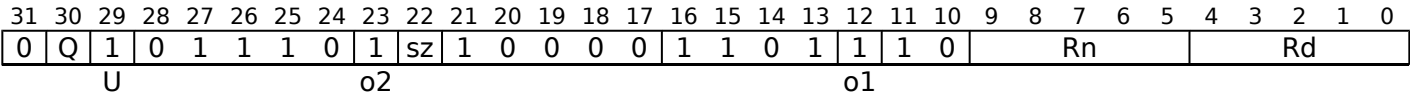
```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

Vector single-precision and double-precision



FCVTZU <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];

bits(esize) element;
FPCRType fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[d] else Zeros();

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPToFixed(element, 0, unsigned, fpcr, rounding);

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## FCVTZU (scalar, fixed-point)

Floating-point Convert to Unsigned fixed-point, rounding toward Zero (scalar). This instruction converts the floating-point value in the SIMD&FP source register to a 32-bit or 64-bit fixed-point unsigned integer using the Round towards Zero rounding mode, and writes the result to the general-purpose destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf		0	0	1	1	1	1	0	ftype		0	1	1	0	0	1	scale					Rn					Rd				
rmode																opcode															

### Half-precision to 32-bit (sf == 0 && ftype == 11) (FEAT\_FP16)

FCVTZU <Wd>, <Hn>, #<fbits>

### Half-precision to 64-bit (sf == 1 && ftype == 11) (FEAT\_FP16)

FCVTZU <Xd>, <Hn>, #<fbits>

### Single-precision to 32-bit (sf == 0 && ftype == 00)

FCVTZU <Wd>, <Sn>, #<fbits>

### Single-precision to 64-bit (sf == 1 && ftype == 00)

FCVTZU <Xd>, <Sn>, #<fbits>

### Double-precision to 32-bit (sf == 0 && ftype == 01)

FCVTZU <Wd>, <Dn>, #<fbits>

### Double-precision to 64-bit (sf == 1 && ftype == 01)

FCVTZU <Xd>, <Dn>, #<fbits>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;

case ftype of
    when '00' fltsize = 32;
    when '01' fltsize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            fltsize = 16;
        else
            UNDEFINED;

if sf == '0' && scale<5> == '0' then UNDEFINED;
integer fracbits = 64 - UInt(scale);
```



## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Hn>	Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Dn>	Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<fbits>	For the double-precision to 32-bit, half-precision to 32-bit and single-precision to 32-bit variant: is the number of bits after the binary point in the fixed-point destination, in the range 1 to 32, encoded as 64 minus "scale".  For the double-precision to 64-bit, half-precision to 64-bit and single-precision to 64-bit variant: is the number of bits after the binary point in the fixed-point destination, in the range 1 to 64, encoded as 64 minus "scale".

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
FPCRTType fpcr = FPCR[];  
bits(fltsize) fltval;  
bits(intsize) intval;  
  
fltval = V[n];  
intval = FPToFixed(fltval, fracbits, TRUE, fpcr, FPRounding_ZERO);  
X[d] = intval;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

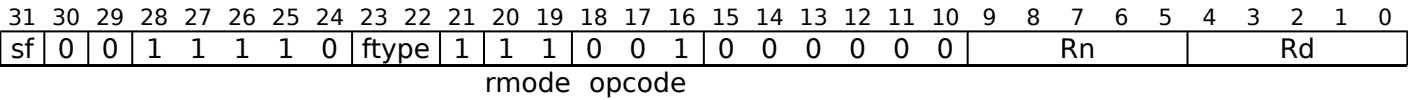
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FCVTZU (scalar, integer)

Floating-point Convert to Unsigned integer, rounding toward Zero (scalar). This instruction converts the floating-point value in the SIMD&FP source register to a 32-bit or 64-bit unsigned integer using the Round towards Zero rounding mode, and writes the result to the general-purpose destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



**Half-precision to 32-bit (sf == 0 && ftype == 11)**  
(FEAT\_FP16)

FCVTZU <Wd>, <Hn>

**Half-precision to 64-bit (sf == 1 && ftype == 11)**  
(FEAT\_FP16)

FCVTZU <Xd>, <Hn>

**Single-precision to 32-bit (sf == 0 && ftype == 00)**

FCVTZU <Wd>, <Sn>

**Single-precision to 64-bit (sf == 1 && ftype == 00)**

FCVTZU <Xd>, <Sn>

**Double-precision to 32-bit (sf == 0 && ftype == 01)**

FCVTZU <Wd>, <Dn>

**Double-precision to 64-bit (sf == 1 && ftype == 01)**

FCVTZU <Xd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;
FPRounding rounding;

case ftype of
  when '00'
    fltsize = 32;
  when '01'
    fltsize = 64;
  when '10'
    UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;

rounding = FPDecodeRounding(rmode);
```

**Assembler Symbols**

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Hn>	Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Dn>	Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
FPCRType fpcr = FPCR[];  
bits(fltsize) fltval;  
bits(intsize) intval;  
  
fltval = V[n];  
intval = FPToFixed(fltval, 0, TRUE, fpcr, rounding);  
X[d] = intval;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FDIV (vector)

Floating-point Divide (vector). This instruction divides the floating-point values in the elements in the first source SIMD&FP register, by the floating-point values in the corresponding elements in the second source SIMD&FP register, places the results in a vector, and writes the vector to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

Half-precision  
(FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	1	0	Rm				0	0	1	1	1	1	Rn				Rd						

FDIV <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	sz	1	Rm				1	1	1	1	1	1	Rn				Rd						

FDIV <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T>

For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = FPDiv(element1, element2, FPCR[]);

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## FDIV (scalar)

Floating-point Divide (scalar). This instruction divides the floating-point value of the first source SIMD&FP register by the floating-point value of the second source SIMD&FP register, and writes the result to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1	1	1	1	0	ftype			1	Rm				0	0	0	1	1	0	Rn				Rd					

### Half-precision (ftype == 11) (FEAT\_FP16)

FDIV <Hd>, <Hn>, <Hm>

### Single-precision (ftype == 00)

FDIV <Sd>, <Sn>, <Sm>

### Double-precision (ftype == 01)

FDIV <Dd>, <Dn>, <Dm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer esize;
case ftype of
    when '00' esize = 32;
    when '01' esize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            esize = 16;
        else
            UNDEFINED;
```

## Assembler Symbols

<Dd>	Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Dn>	Is the 64-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
<Dm>	Is the 64-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
<Hd>	Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Hn>	Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
<Hm>	Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
<Sd>	Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
<Sm>	Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
bits(esize) operand1 = V[n];  
bits(esize) operand2 = V[m];  
  
FPCRType fpcr = FPCR[];  
boolean merge = IsMerging(fpcr);  
bits(128) result = if merge then V[n] else Zeros();  
  
Elem[result, 0, esize] = FPDiv(operand1, operand2, FPCR[]);  
  
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

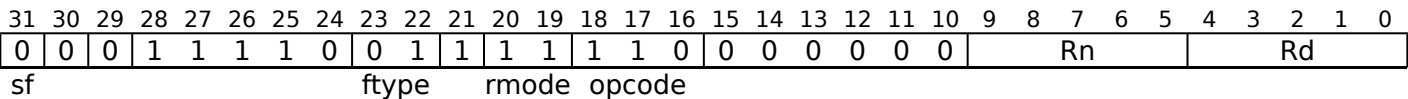
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



FJCVTZS

Floating-point Javascript Convert to Signed fixed-point, rounding toward Zero. This instruction converts the double-precision floating-point value in the SIMD&FP source register to a 32-bit signed integer using the Round towards Zero rounding mode, and writes the result to the general-purpose destination register. If the result is too large to be represented as a signed 32-bit integer, then the result is the integer modulo 2<sup>32</sup>, as held in a 32-bit signed integer. This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*. Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

Double-precision to 32-bit (FEAT\_JSCVT)



FJCVTZS <Wd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if !HaveFJCVTZSExt() then UNDEFINED;
```

Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();

FPCRTyp fpcr = FPCR[];
bits(64) fltval;
bits(32) intval;

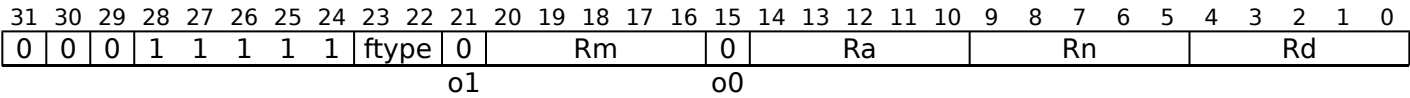
bit Z;
fltval = V[n];
(intval, Z) = FPToFixedJS(fltval, fpcr, TRUE);
PSTATE.<N,Z,C,V> = '0':Z:'00';
X[d] = intval;
```

# FMADD

Floating-point fused Multiply-Add (scalar). This instruction multiplies the values of the first two SIMD&FP source registers, adds the product to the value of the third SIMD&FP source register, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (FEAT\_FP16)

FMADD <Hd>, <Hn>, <Hm>, <Ha>

## Single-precision (ftype == 00)

FMADD <Sd>, <Sn>, <Sm>, <Sa>

## Double-precision (ftype == 01)

FMADD <Dd>, <Dn>, <Dm>, <Da>

```
integer d = UInt(Rd);
integer a = UInt(Ra);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer esize;
case ftype of
  when '00' esize = 32;
  when '01' esize = 64;
  when '10' UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      esize = 16;
    else
      UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the first SIMD&FP source register holding the multiplicand, encoded in the "Rn" field.
- <Dm> Is the 64-bit name of the second SIMD&FP source register holding the multiplier, encoded in the "Rm" field.
- <Da> Is the 64-bit name of the third SIMD&FP source register holding the addend, encoded in the "Ra" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register holding the multiplicand, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register holding the multiplier, encoded in the "Rm" field.
- <Ha> Is the 16-bit name of the third SIMD&FP source register holding the addend, encoded in the "Ra" field.

<Sd>	Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the first SIMD&FP source register holding the multiplicand, encoded in the "Rn" field.
<Sm>	Is the 32-bit name of the second SIMD&FP source register holding the multiplier, encoded in the "Rm" field.
<Sa>	Is the 32-bit name of the third SIMD&FP source register holding the addend, encoded in the "Ra" field.

## Operation

```

CheckFPAdvSIMDEnabled64();

bits(esize) operanda = V[a];
bits(esize) operand1 = V[n];
bits(esize) operand2 = V[m];

FPCRType fpcr = FPCR[];
boolean merge = IsMerging(fpcr);
bits(128) result = if merge then V[a] else Zeros();

Elem[result, 0, esize] = FPMulAdd(operanda, operand1, operand2, fpcr);

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## FMAX (vector)

Floating-point Maximum (vector). This instruction compares corresponding vector elements in the two source SIMD&FP registers, places the larger of each of the two floating-point values into a vector, and writes the vector to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

### Half-precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	1	0	Rm				0	0	1	1	0	1	Rn				Rd						
U								o1																							

**FMAX** <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

```
boolean pair = (U == '1');
boolean minimum = (o1 == '1');
```

### Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	sz	1	Rm				1	1	1	1	0	1	Rn				Rd						
U								o1																							

**FMAX** <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

```
boolean pair = (U == '1');
boolean minimum = (o1 == '1');
```

### Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(2*datasize) concat = operand2:operand1;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    if pair then
        element1 = Elem[concat, 2*e, esize];
        element2 = Elem[concat, (2*e)+1, esize];
    else
        element1 = Elem[operand1, e, esize];
        element2 = Elem[operand2, e, esize];

    if minimum then
        Elem[result, e, esize] = FPMIn(element1, element2, FPCR[]);
    else
        Elem[result, e, esize] = FPMax(element1, element2, FPCR[]);

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

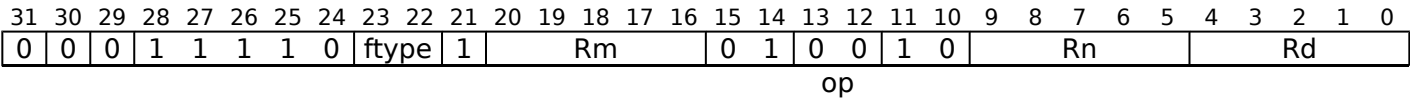
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FMAX (scalar)

Floating-point Maximum (scalar). This instruction compares the two source SIMD&FP registers, and writes the larger of the two floating-point values to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (FEAT\_FP16)

FMAX <Hd>, <Hn>, <Hm>

## Single-precision (ftype == 00)

FMAX <Sd>, <Sn>, <Sm>

## Double-precision (ftype == 01)

FMAX <Dd>, <Dn>, <Dm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer esize;
case ftype of
    when '00' esize = 32;
    when '01' esize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            esize = 16;
        else
            UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Dm> Is the 64-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Sm> Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
bits(esize) operand1 = V[n];  
bits(esize) operand2 = V[m];  
  
FPCRTYPE fpcr = FPCR[];  
boolean merge = IsMerging(fpcr);  
bits(128) result = if merge then V[n] else Zeros();  
  
Elem[result, 0, esize] = FPMAX(operand1, operand2, fpcr);  
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## FMAXNM (vector)

Floating-point Maximum Number (vector). This instruction compares corresponding vector elements in the two source SIMD&FP registers, writes the larger of the two floating-point values into a vector, and writes the vector to the destination SIMD&FP register.

NaNs are handled according to the IEEE 754-2008 standard. If one vector element is numeric and the other is a quiet NaN, the result placed in the vector is the numerical value, otherwise the result is identical to *FMAX (scalar)*.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

### Half-precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	1	0	Rm				0	0	0	0	0	1	Rn				Rd						
U								a																							

**FMAXNM** <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
boolean minimum = (a == '1');
```

### Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	sz	1	Rm				1	1	0	0	0	1	Rn				Rd						
U								o1																							

**FMAXNM** <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
boolean minimum = (o1 == '1');
```

### Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":



Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(2*datasize) concat = operand2:operand1;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    if pair then
        element1 = Elem[concat, 2*e, esize];
        element2 = Elem[concat, (2*e)+1, esize];
    else
        element1 = Elem[operand1, e, esize];
        element2 = Elem[operand2, e, esize];

    if minimum then
        Elem[result, e, esize] = FPMinNum(element1, element2, FPCR[]);
    else
        Elem[result, e, esize] = FPMaxNum(element1, element2, FPCR[]);

V[d] = result;

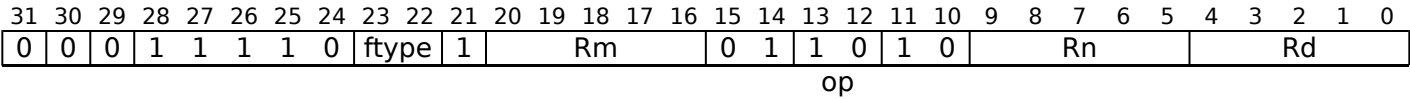
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FMAXNM (scalar)

Floating-point Maximum Number (scalar). This instruction compares the first and second source SIMD&FP register values, and writes the larger of the two floating-point values to the destination SIMD&FP register. NaNs are handled according to the IEEE 754-2008 standard. If one vector element is numeric and the other is a quiet NaN, the result that is placed in the vector is the numerical value, otherwise the result is identical to *FMAX (scalar)*. This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*. Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Half-precision (ftype == 11)  
(FEAT\_FP16)

FMAXNM <Hd>, <Hn>, <Hm>

Single-precision (ftype == 00)

FMAXNM <Sd>, <Sn>, <Sm>

Double-precision (ftype == 01)

FMAXNM <Dd>, <Dn>, <Dm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer esize;
case ftype of
    when '00' esize = 32;
    when '01' esize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            esize = 16;
        else
            UNDEFINED;
```

## Assembler Symbols

- <Dd>

Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn>

Is the 64-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Dm>

Is the 64-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Hd>

Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn>

Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm>

Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Sd>

Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn>

Is the 32-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Sm>

Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
bits(esize) operand1 = V[n];  
bits(esize) operand2 = V[m];  
  
FPCRTYPE fpcr = FPCR[];  
boolean merge = IsMerging(fpcr);  
bits(128) result = if merge then V[n] else Zeros();  
  
Elem[result, 0, esize] = FPMAXNUM(operand1, operand2, fpcr);  
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FMAXNMP (scalar)

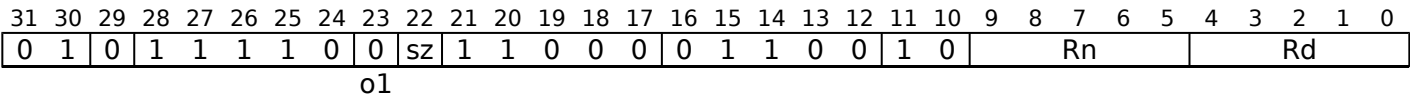
Floating-point Maximum Number of Pair of elements (scalar). This instruction compares two vector elements in the source SIMD&FP register and writes the largest of the floating-point values as a scalar to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR EL1*, *CPTR EL2*, and *CPTR EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (FEAT\_FP16)



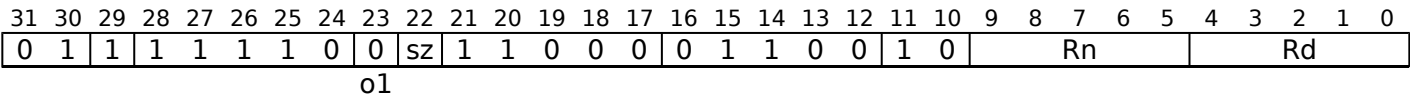
FMAXNMP <V><d>, <Vn>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
if sz == '1' then UNDEFINED;
integer datasize = 32;
```

## Single-precision and double-precision



FMAXNMP <V><d>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize * 2;
```

## Assembler Symbols

<V> For the half-precision variant: is the destination width specifier, encoded in “sz”:

sz	<V>
0	H
1	RESERVED

For the single-precision and double-precision variant: is the destination width specifier, encoded in “sz”:

sz	<V>
0	S
1	D

<d> Is the number of the SIMD&FP destination register, encoded in the “Rd” field.

<Vn>

Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<T>

For the half-precision variant: is the source arrangement specifier, encoded in "sz":

sz	<T>
0	2H
1	RESERVED

For the single-precision and double-precision variant: is the source arrangement specifier, encoded in "sz":

sz	<T>
0	2S
1	2D

Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
V[d] = Reduce(ReduceOp_FMAXNUM, operand, esize, FALSE);

```

# FMAXNMP (vector)

Floating-point Maximum Number Pairwise (vector). This instruction creates a vector by concatenating the vector elements of the first source SIMD&FP register after the vector elements of the second source SIMD&FP register, reads each pair of adjacent vector elements in the two source SIMD&FP registers, writes the largest of each pair of values into a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are floating-point values.

NaNs are handled according to the IEEE 754-2008 standard. If one vector element is numeric and the other is a quiet NaN, the result is the numerical value, otherwise the result is identical to *FMAX (scalar)*.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	1	0	Rm				0	0	0	0	0	1	Rn				Rd						
U								a																							

FMAXNMP <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
boolean minimum = (a == '1');
```

## Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	sz	1	Rm				1	1	0	0	0	1	Rn				Rd						
U								o1																							

FMAXNMP <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
boolean minimum = (o1 == '1');
```

## Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in “Q”:

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in “sz:Q”:

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(2*datasize) concat = operand2:operand1;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    if pair then
        element1 = Elem[concat, 2*e, esize];
        element2 = Elem[concat, (2*e)+1, esize];
    else
        element1 = Elem[operand1, e, esize];
        element2 = Elem[operand2, e, esize];

    if minimum then
        Elem[result, e, esize] = FPMinNum(element1, element2, FPCR[]);
    else
        Elem[result, e, esize] = FPMaxNum(element1, element2, FPCR[]);

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FMAXNMV

Floating-point Maximum Number across Vector. This instruction compares all the vector elements in the source SIMD&FP register, and writes the largest of the values as a scalar to the destination SIMD&FP register. All the values in this instruction are floating-point values.

NaNs are handled according to the IEEE 754-2008 standard. If one vector element is numeric and the other is a quiet NaN, the result of the comparison is the numerical value, otherwise the result is identical to *FMAX (scalar)*.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

Half-precision  
(FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	0	1	1	0	0	0	0	1	1	0	0	1	0	Rn				Rd					
o1																															

FMAXNMV <V><d>, <Vn>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
```

Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	sz	1	1	0	0	0	0	1	1	0	0	1	0	Rn				Rd					
o1																															

FMAXNMV <V><d>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q != '01' then UNDEFINED;    // .4S only

integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
```

Assembler Symbols

- <V>

For the half-precision variant: is the destination width specifier, H.
- For the single-precision and double-precision variant: is the destination width specifier, encoded in "sz":

sz	<V>
0	S
1	RESERVED
- <d>

Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vn>

Is the name of the SIMD&FP source register, encoded in the "Rn" field.



<T> For the half-precision variant: is an arrangement specifier, encoded in “Q”:

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in “Q:sz”:

Q	sz	<T>
0	x	RESERVED
1	0	4S
1	1	RESERVED

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
V[d] = Reduce(ReduceOp_FMAXNUM, operand, esize, FALSE);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41  
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FMAXP (scalar)

Floating-point Maximum of Pair of elements (scalar). This instruction compares two vector elements in the source SIMD&FP register and writes the largest of the floating-point values as a scalar to the destination SIMD&FP register. This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	sz	1	1	0	0	0	0	1	1	1	1	1	0	Rn				Rd					
o1																															

FMAXP <V><d>, <Vn>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
if sz == '1' then UNDEFINED;
integer datasize = 32;
```

## Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	0	sz	1	1	0	0	0	0	1	1	1	1	1	0	Rn				Rd					
o1																															

FMAXP <V><d>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize * 2;
```

## Assembler Symbols

<V> For the half-precision variant: is the destination width specifier, encoded in “sz”:

sz	<V>
0	H
1	RESERVED

For the single-precision and double-precision variant: is the destination width specifier, encoded in “sz”:

sz	<V>
0	S
1	D

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<T> For the half-precision variant: is the source arrangement specifier, encoded in “sz”:

sz	<T>
0	2H
1	RESERVED

For the single-precision and double-precision variant: is the source arrangement specifier, encoded in “sz”:

sz	<T>
0	2S
1	2D

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
V[d] = Reduce(ReduceOp_FMAX, operand, esize);
```

# FMAXP (vector)

Floating-point Maximum Pairwise (vector). This instruction creates a vector by concatenating the vector elements of the first source SIMD&FP register after the vector elements of the second source SIMD&FP register, reads each pair of adjacent vector elements from the concatenated vector, writes the larger of each pair of values into a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are floating-point values. This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*. Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	1	0	Rm				0	0	1	1	0	1	Rn				Rd						
U								o1																							

FMAXP <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
boolean minimum = (o1 == '1');
```

## Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	sz	1	Rm					1	1	1	1	0	1	Rn					Rd				
U								o1																							

FMAXP <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
boolean minimum = (o1 == '1');
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(2*datasize) concat = operand2:operand1;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    if pair then
        element1 = Elem[concat, 2*e, esize];
        element2 = Elem[concat, (2*e)+1, esize];
    else
        element1 = Elem[operand1, e, esize];
        element2 = Elem[operand2, e, esize];

    if minimum then
        Elem[result, e, esize] = FPMIn(element1, element2, FPCR[]);
    else
        Elem[result, e, esize] = FPMax(element1, element2, FPCR[]);

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FMAXV

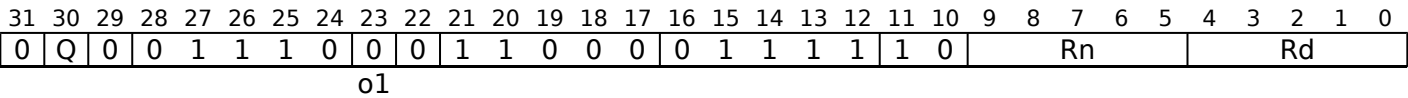
Floating-point Maximum across Vector. This instruction compares all the vector elements in the source SIMD&FP register, and writes the largest of the values as a scalar to the destination SIMD&FP register. All the values in this instruction are floating-point values.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

Half-precision  
(FEAT\_FP16)



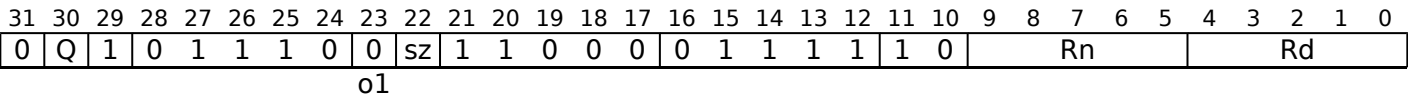
FMAXV <V><d>, <Vn>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
```

Single-precision and double-precision



FMAXV <V><d>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q != '01' then UNDEFINED;

integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
```

Assembler Symbols

- <V> For the half-precision variant: is the destination width specifier, H.
- For the single-precision and double-precision variant: is the destination width specifier, encoded in “sz”:

sz	<V>
0	S
1	RESERVED
- <d> Is the number of the SIMD&FP destination register, encoded in the “Rd” field.
- <Vn> Is the name of the SIMD&FP source register, encoded in the “Rn” field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in “Q”:

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in “Q:sz”:

Q	sz	<T>
0	x	RESERVED
1	0	4S
1	1	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
V[d] = Reduce(ReduceOp_FMAX, operand, esize);

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FMIN (vector)

Floating-point minimum (vector). This instruction compares corresponding elements in the vectors in the two source SIMD&FP registers, places the smaller of each of the two floating-point values into a vector, and writes the vector to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	1	0	Rm				0	0	1	1	0	1	Rn				Rd						
U								o1																							

FMIN <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
boolean minimum = (o1 == '1');
```

## Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	sz	1	Rm				1	1	1	1	0	1	Rn				Rd						
U								o1																							

FMIN <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
boolean minimum = (o1 == '1');
```

## Assembler Symbols

- <Vd>
- Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T>
- For the half-precision variant: is an arrangement specifier, encoded in "Q":



Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(2*datasize) concat = operand2:operand1;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    if pair then
        element1 = Elem[concat, 2*e, esize];
        element2 = Elem[concat, (2*e)+1, esize];
    else
        element1 = Elem[operand1, e, esize];
        element2 = Elem[operand2, e, esize];

    if minimum then
        Elem[result, e, esize] = FPMIn(element1, element2, FPCR[]);
    else
        Elem[result, e, esize] = FPMax(element1, element2, FPCR[]);

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

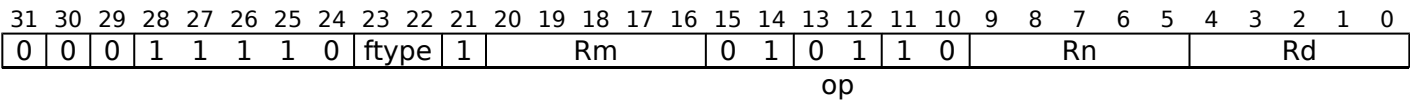
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FMIN (scalar)

Floating-point Minimum (scalar). This instruction compares the first and second source SIMD&FP register values, and writes the smaller of the two floating-point values to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (FEAT\_FP16)

FMIN <Hd>, <Hn>, <Hm>

## Single-precision (ftype == 00)

FMIN <Sd>, <Sn>, <Sm>

## Double-precision (ftype == 01)

FMIN <Dd>, <Dn>, <Dm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer esize;
case ftype of
    when '00' esize = 32;
    when '01' esize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            esize = 16;
        else
            UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Dm> Is the 64-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Sm> Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
bits(esize) operand1 = V[n];  
bits(esize) operand2 = V[m];  
  
FPCRTYPE fpcr = FPCR[];  
boolean merge = IsMerging(fpcr);  
bits(128) result = if merge then V[n] else Zeros();  
  
Elem[result, 0, esize] = FPMIn(operand1, operand2, fpcr);  
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FMINNM (vector)

Floating-point Minimum Number (vector). This instruction compares corresponding vector elements in the two source SIMD&FP registers, writes the smaller of the two floating-point values into a vector, and writes the vector to the destination SIMD&FP register.

NaNs are handled according to the IEEE 754-2008 standard. If one vector element is numeric and the other is a quiet NaN, the result placed in the vector is the numerical value, otherwise the result is identical to *FMIN (scalar)*.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	1	0	Rm				0	0	0	0	0	1	Rn				Rd						
U								a																							

FMINNM <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
boolean minimum = (a == '1');
```

## Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	sz	1	Rm					1	1	0	0	0	1	Rn					Rd				
U								o1																							

FMINNM <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
boolean minimum = (o1 == '1');
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(2*datasize) concat = operand2:operand1;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    if pair then
        element1 = Elem[concat, 2*e, esize];
        element2 = Elem[concat, (2*e)+1, esize];
    else
        element1 = Elem[operand1, e, esize];
        element2 = Elem[operand2, e, esize];

    if minimum then
        Elem[result, e, esize] = FPMinNum(element1, element2, FPCR[]);
    else
        Elem[result, e, esize] = FPMaxNum(element1, element2, FPCR[]);

V[d] = result;

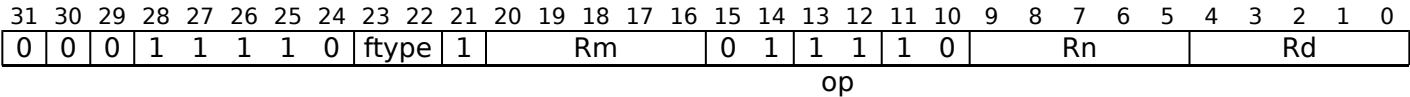
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FMINNM (scalar)

Floating-point Minimum Number (scalar). This instruction compares the first and second source SIMD&FP register values, and writes the smaller of the two floating-point values to the destination SIMD&FP register. NaNs are handled according to the IEEE 754-2008 standard. If one vector element is numeric and the other is a quiet NaN, the result that is placed in the vector is the numerical value, otherwise the result is identical to *FMIN (scalar)*. This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*. Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Half-precision (ftype == 11)  
(FEAT\_FP16)

FMINNM <Hd>, <Hn>, <Hm>

Single-precision (ftype == 00)

FMINNM <Sd>, <Sn>, <Sm>

Double-precision (ftype == 01)

FMINNM <Dd>, <Dn>, <Dm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer esize;
case ftype of
    when '00' esize = 32;
    when '01' esize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            esize = 16;
        else
            UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Dm> Is the 64-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Sm> Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
bits(esize) operand1 = V[n];  
bits(esize) operand2 = V[m];  
  
FPCRTYPE fpcr = FPCR[];  
boolean merge = IsMerging(fpcr);  
bits(128) result = if merge then V[n] else Zeros();  
  
Elem[result, 0, esize] = FPMINNum(operand1, operand2, fpcr);  
  
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FMINNMP (scalar)

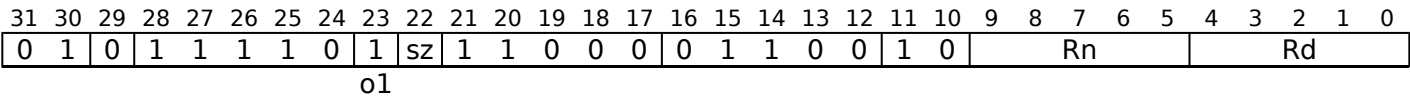
Floating-point Minimum Number of Pair of elements (scalar). This instruction compares two vector elements in the source SIMD&FP register and writes the smallest of the floating-point values as a scalar to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR EL1*, *CPTR EL2*, and *CPTR EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

Half-precision  
(FEAT\_FP16)



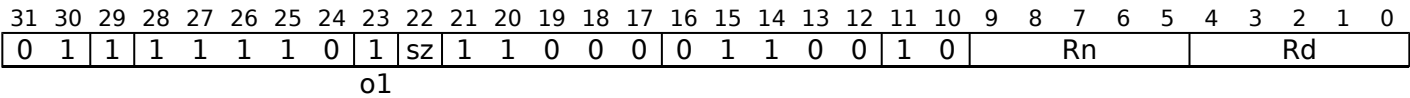
FMINNMP <V><d>, <Vn>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
if sz == '1' then UNDEFINED;
integer datasize = 32;
```

Single-precision and double-precision



FMINNMP <V><d>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize * 2;
```

Assembler Symbols

<V> For the half-precision variant: is the destination width specifier, encoded in “sz”:

sz	<V>
0	H
1	RESERVED

For the single-precision and double-precision variant: is the destination width specifier, encoded in “sz”:

sz	<V>
0	S
1	D

<d> Is the number of the SIMD&FP destination register, encoded in the “Rd” field.



<Vn>

Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<T>

For the half-precision variant: is the source arrangement specifier, encoded in "sz":

sz	<T>
0	2H
1	RESERVED

For the single-precision and double-precision variant: is the source arrangement specifier, encoded in "sz":

sz	<T>
0	2S
1	2D

Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
V[d] = Reduce(ReduceOp_FMINNUM, operand, esize, FALSE);

```

## FMINNMP (vector)

Floating-point Minimum Number Pairwise (vector). This instruction creates a vector by concatenating the vector elements of the first source SIMD&FP register after the vector elements of the second source SIMD&FP register, reads each pair of adjacent vector elements in the two source SIMD&FP registers, writes the smallest of each pair of floating-point values into a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are floating-point values.

NaNs are handled according to the IEEE 754-2008 standard. If one vector element is numeric and the other is a quiet NaN, the result is the numerical value, otherwise the result is identical to *FMIN (scalar)*.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

### Half-precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	1	0	Rm				0	0	0	0	0	1	Rn				Rd						
U								a																							

**FMINNMP** <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
boolean minimum = (a == '1');
```

### Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	sz	1	Rm				1	1	0	0	0	1	Rn				Rd						
U								o1																							

**FMINNMP** <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
boolean minimum = (o1 == '1');
```

### Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in “Q”:

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in “sz:Q”:

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(2*datasize) concat = operand2:operand1;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    if pair then
        element1 = Elem[concat, 2*e, esize];
        element2 = Elem[concat, (2*e)+1, esize];
    else
        element1 = Elem[operand1, e, esize];
        element2 = Elem[operand2, e, esize];

    if minimum then
        Elem[result, e, esize] = FPMinNum(element1, element2, FPCR[]);
    else
        Elem[result, e, esize] = FPMaxNum(element1, element2, FPCR[]);

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FMINNMV

Floating-point Minimum Number across Vector. This instruction compares all the vector elements in the source SIMD&FP register, and writes the smallest of the values as a scalar to the destination SIMD&FP register. All the values in this instruction are floating-point values.

NaNs are handled according to the IEEE 754-2008 standard. If one vector element is numeric and the other is a quiet NaN, the result of the comparison is the numerical value, otherwise the result is identical to *FMIN (scalar)*.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

Half-precision  
(FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	0	1	1	0	0	0	0	1	1	0	0	1	0	Rn				Rd					
o1																															

FMINNMV <V><d>, <Vn>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
```

Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	sz	1	1	0	0	0	0	1	1	0	0	1	0	Rn				Rd					
o1																															

FMINNMV <V><d>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q != '01' then UNDEFINED;    // .4S only

integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
```

Assembler Symbols

- <V>For the half-precision variant: is the destination width specifier, H.
- For the single-precision and double-precision variant: is the destination width specifier, encoded in “sz”:

sz	<V>
0	S
1	RESERVED
- <d>Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vn>Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in “Q”:

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in “Q:sz”:

Q	sz	<T>
0	x	RESERVED
1	0	4S
1	1	RESERVED

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
V[d] = Reduce(ReduceOp_FMINNUM, operand, esize, FALSE);
```

# FMINP (scalar)

Floating-point Minimum of Pair of elements (scalar). This instruction compares two vector elements in the source SIMD&FP register and writes the smallest of the floating-point values as a scalar to the destination SIMD&FP register. This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	1	sz	1	1	0	0	0	0	1	1	1	1	1	0	Rn				Rd					
o1																															

FMINP <V><d>, <Vn>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
if sz == '1' then UNDEFINED;
integer datasize = 32;
```

## Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	1	sz	1	1	0	0	0	0	1	1	1	1	1	0	Rn				Rd					
o1																															

FMINP <V><d>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize * 2;
```

## Assembler Symbols

<V> For the half-precision variant: is the destination width specifier, encoded in “sz”:

sz	<V>
0	H
1	RESERVED

For the single-precision and double-precision variant: is the destination width specifier, encoded in “sz”:

sz	<V>
0	S
1	D

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<T> For the half-precision variant: is the source arrangement specifier, encoded in “sz”:

sz	<T>
0	2H
1	RESERVED

For the single-precision and double-precision variant: is the source arrangement specifier, encoded in “sz”:

sz	<T>
0	2S
1	2D

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
V[d] = Reduce(ReduceOp_FMIN, operand, esize);
```

# FMINP (vector)

Floating-point Minimum Pairwise (vector). This instruction creates a vector by concatenating the vector elements of the first source SIMD&FP register after the vector elements of the second source SIMD&FP register, reads each pair of adjacent vector elements from the concatenated vector, writes the smaller of each pair of values into a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are floating-point values. This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*. Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	1	0	Rm				0	0	1	1	0	1	Rn				Rd						
U								o1																							

FMINP <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
boolean minimum = (o1 == '1');
```

## Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	sz	1	Rm				1	1	1	1	0	1	Rn				Rd						
U								o1																							

FMINP <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
boolean minimum = (o1 == '1');
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":



Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(2*datasize) concat = operand2:operand1;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    if pair then
        element1 = Elem[concat, 2*e, esize];
        element2 = Elem[concat, (2*e)+1, esize];
    else
        element1 = Elem[operand1, e, esize];
        element2 = Elem[operand2, e, esize];

    if minimum then
        Elem[result, e, esize] = FPMIn(element1, element2, FPCR[]);
    else
        Elem[result, e, esize] = FPMax(element1, element2, FPCR[]);

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FMINV

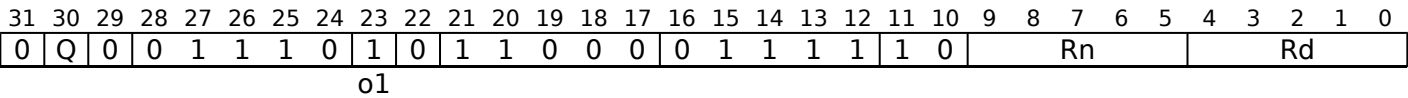
Floating-point Minimum across Vector. This instruction compares all the vector elements in the source SIMD&FP register, and writes the smallest of the values as a scalar to the destination SIMD&FP register. All the values in this instruction are floating-point values.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

Half-precision  
(FEAT\_FP16)



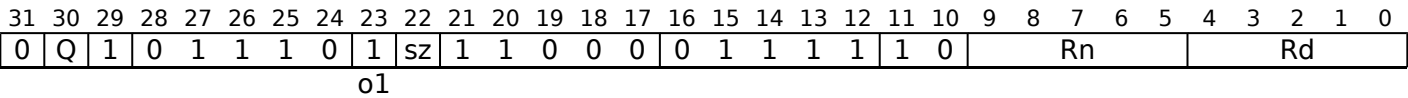
FMINV <V><d>, <Vn>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
```

Single-precision and double-precision



FMINV <V><d>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q != '01' then UNDEFINED;

integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
```

Assembler Symbols

- <V> For the half-precision variant: is the destination width specifier, H.
- For the single-precision and double-precision variant: is the destination width specifier, encoded in “sz”:

sz	<V>
0	S
1	RESERVED
- <d> Is the number of the SIMD&FP destination register, encoded in the “Rd” field.
- <Vn> Is the name of the SIMD&FP source register, encoded in the “Rn” field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in “Q”:

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in “Q:sz”:

Q	sz	<T>
0	x	RESERVED
1	0	4S
1	1	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
V[d] = Reduce(ReduceOp_FMIN, operand, esize);

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## FMLA (by element)

Floating-point fused Multiply-Add to accumulator (by element). This instruction multiplies the vector elements in the first source SIMD&FP register by the specified value in the second source SIMD&FP register, and accumulates the results in the vector elements of the destination SIMD&FP register. All the values in this instruction are floating-point values.

This instruction can generate a floating-point exception. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#) or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar, half-precision](#) , [Scalar, single-precision and double-precision](#) , [Vector, half-precision](#) and [Vector, single-precision and double-precision](#)

### Scalar, half-precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	0	0	L	M			Rm		0	0	0	1	H	0								Rd		
																o2															

**FMLA** <Hd>, <Hn>, <Vm>.H[<index>]

```
if !HaveFP16Ext() then UNDEFINED;

integer idxdsize = if H == '1' then 128 else 64;
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Rd);
integer index = UInt(H:L:M);

integer esize = 16;
integer datasize = esize;
integer elements = 1;
boolean sub_op = (o2 == '1');
```

### Scalar, single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	1	sz	L	M			Rm		0	0	0	1	H	0								Rd		
																o2															

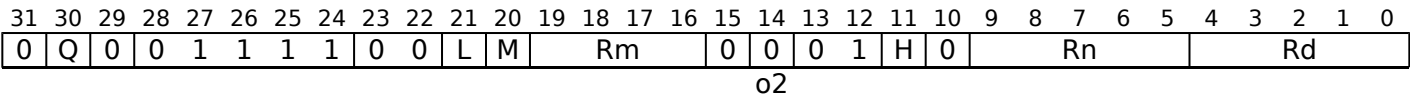
**FMLA** <V><d>, <V><n>, <Vm>.<Ts>[<index>]

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi = M;
case sz:L of
  when '0x' index = UInt(H:L);
  when '10' index = UInt(H);
  when '11' UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
boolean sub_op = (o2 == '1');
```

Vector, half-precision  
(FEAT\_FP16)



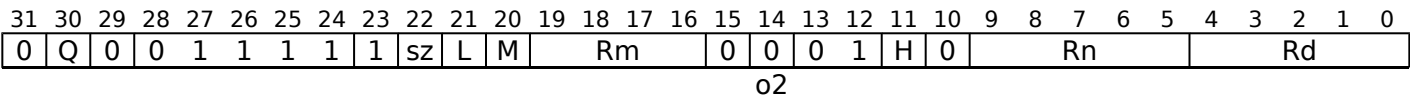
FMLA <Vd>.<T>, <Vn>.<T>, <Vm>.H[<index>]

```
if !HaveFP16Ext() then UNDEFINED;

integer idxdsize = if H == '1' then 128 else 64;
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Rd);
integer index = UInt(H:L:M);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean sub_op = (o2 == '1');
```

Vector, single-precision and double-precision



FMLA <Vd>.<T>, <Vn>.<T>, <Vm>.<Ts>[<index>]

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi = M;
case sz:L of
    when '0x' index = UInt(H:L);
    when '10' index = UInt(H);
    when '11' UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean sub_op = (o2 == '1');
```

Assembler Symbols

- <Hd>

Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn>

Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <V>

Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D
- <d>

Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n>

Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "Q:sz":

Q	sz	<T>
0	0	2S
0	1	RESERVED
1	0	4S
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> For the half-precision variant: is the name of the second SIMD&FP source register, in the range V0 to V15, encoded in the "Rm" field.

For the single-precision and double-precision variant: is the name of the second SIMD&FP source register, encoded in the "M:Rm" fields.

<Ts> Is an element size specifier, encoded in "sz":

sz	<Ts>
0	S
1	D

<index> For the half-precision variant: is the element index, in the range 0 to 7, encoded in the "H:L:M" fields.

For the single-precision and double-precision variant: is the element index, encoded in "sz:L:H":

sz	L	<index>
0	x	H:L
1	0	H
1	1	RESERVED

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(idxdsize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(esize) element1;
bits(esize) element2 = Elem[operand2, index, esize];
FPCRType fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[d] else Zeros();

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    if sub_op then element1 = FPNeg(element1);
    Elem[result, e, esize] = FPMulAdd(Elem[operand3, e, esize], element1, element2, fpcr);

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FMLA (vector)

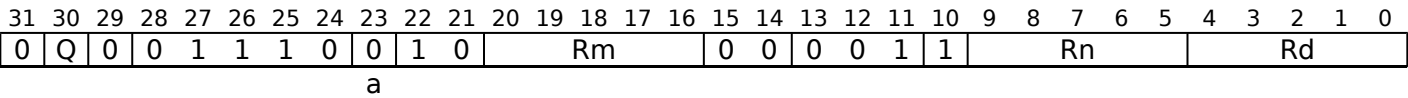
Floating-point fused Multiply-Add to accumulator (vector). This instruction multiplies corresponding floating-point values in the vectors in the two source SIMD&FP registers, adds the product to the corresponding vector element of the destination SIMD&FP register, and writes the result to the destination SIMD&FP register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (FEAT\_FP16)



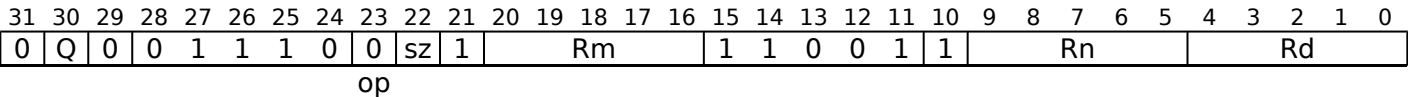
FMLA <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean sub_op = (a == '1');
```

## Single-precision and double-precision



FMLA <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean sub_op = (op == '1');
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    if sub_op then element1 = FPNeg(element1);
    Elem[result, e, esize] = FPMulAdd(Elem[operand3, e, esize], element1, element2, FPCR[]);
V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



## FMLAL, FMLAL2 (by element)

Floating-point fused Multiply-Add Long to accumulator (by element). This instruction multiplies the vector elements in the first source SIMD&FP register by the specified value in the second source SIMD&FP register, and accumulates the product to the corresponding vector element of the destination SIMD&FP register. The instruction does not round the result of the multiply before the accumulation.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

In Armv8.2 and Armv8.3, this is an OPTIONAL instruction. From Armv8.4 it is mandatory for all implementations to support it.

[ID\\_AA64ISAR0\\_EL1](#).FHM indicates whether this instruction is supported.

It has encodings from 2 classes: [FMLAL](#) and [FMLAL2](#)

### FMLAL (FEAT\_FHM)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	1	0	L	M				Rm		0	0	0	0	H	0								Rd	
SZ												S																			

FMLAL <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<H>[<index>]

```
if !HaveFP16MulNoRoundingToFP32Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt('0':Rm); // Vm can only be in bottom 16 registers.
if sz == '1' then UNDEFINED;
integer index = UInt(H:L:M);

integer esize = 32;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean sub_op = (S == '1');
integer part = 0;
```

### FMLAL2 (FEAT\_FHM)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	1	0	L	M				Rm		1	0	0	0	H	0								Rd	
SZ												S																			

FMLAL2 <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<H>[<index>]

```
if !HaveFP16MulNoRoundingToFP32Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt('0':Rm); // Vm can only be in bottom 16 registers.
if sz == '1' then UNDEFINED;
integer index = UInt(H:L:M);

integer esize = 32;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean sub_op = (S == '1');
integer part = 1;
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Ta> Is an arrangement specifier, encoded in "Q":

Q	<Ta>
0	2S
1	4S

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Tb> Is an arrangement specifier, encoded in "Q":

Q	<Tb>
0	2H
1	4H

- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.
- <index> Is the element index, encoded in the "H:L:M" fields.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize DIV 2) operand1 = Vpart[n, part];
bits(128) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
bits(esize DIV 2) element1;
bits(esize DIV 2) element2 = Elem[operand2, index, esize DIV 2];

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize DIV 2];
    if sub_op then element1 = FPNeg(element1);
    Elem[result, e, esize] = FPMulAddH(Elem[operand3, e, esize], element1, element2, FPCR[]);
V[d] = result;
```

# FMLAL, FMLAL2 (vector)

Floating-point fused Multiply-Add Long to accumulator (vector). This instruction multiplies corresponding half-precision floating-point values in the vectors in the two source SIMD&FP registers, and accumulates the product to the corresponding vector element of the destination SIMD&FP register. The instruction does not round the result of the multiply before the accumulation.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

In Armv8.2 and Armv8.3, this is an OPTIONAL instruction. From Armv8.4 it is mandatory for all implementations to support it.

[ID\\_AA64ISAR0\\_EL1](#).FHM indicates whether this instruction is supported.

It has encodings from 2 classes: [FMLAL](#) and [FMLAL2](#)

## FMLAL (FEAT\_FHM)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	0	1	Rm				1	1	1	0	1	1	Rn				Rd						
S								sz																							

FMLAL <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
if !HaveFP16MulNoRoundingToFP32Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz == '1' then UNDEFINED;
integer esize = 32;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean sub_op = (S == '1');
integer part = 0;
```

## FMLAL2 (FEAT\_FHM)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	0	1	Rm				1	1	0	0	1	1	Rn				Rd						
S								sz																							

FMLAL2 <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
if !HaveFP16MulNoRoundingToFP32Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz == '1' then UNDEFINED;
integer esize = 32;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean sub_op = (S == '1');
integer part = 1;
```

## Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “Q”:

Q	<Ta>
0	2S
1	4S

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “Q”:

Q	<Tb>
0	2H
1	4H

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize DIV 2) operand1 = Vpart[n, part];
bits(datasize DIV 2) operand2 = Vpart[m, part];
bits(datasize) operand3 = V[d];
bits(datasize) result;
bits(esize DIV 2) element1;
bits(esize DIV 2) element2;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize DIV 2];
    element2 = Elem[operand2, e, esize DIV 2];
    if sub_op then element1 = FPNeg(element1);
    Elem[result, e, esize] = FPMulAddH(Elem[operand3, e, esize], element1, element2, FPCR[]);
V[d] = result;
```

## FMLS (by element)

Floating-point fused Multiply-Subtract from accumulator (by element). This instruction multiplies the vector elements in the first source SIMD&FP register by the specified value in the second source SIMD&FP register, and subtracts the results from the vector elements of the destination SIMD&FP register. All the values in this instruction are floating-point values.

This instruction can generate a floating-point exception. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#) or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar, half-precision](#) , [Scalar, single-precision and double-precision](#) , [Vector, half-precision](#) and [Vector, single-precision and double-precision](#)

### Scalar, half-precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	0	0	L	M	Rm			0	1	0	1	H	0	Rn			Rd							
o2																															

**FMLS** <Hd>, <Hn>, <Vm>.H[<index>]

```
if !HaveFP16Ext() then UNDEFINED;

integer idxdsize = if H == '1' then 128 else 64;
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Rd);
integer index = UInt(H:L:M);

integer esize = 16;
integer datasize = esize;
integer elements = 1;
boolean sub_op = (o2 == '1');
```

### Scalar, single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	1	sz	L	M	Rm			0	1	0	1	H	0	Rn			Rd							
o2																															

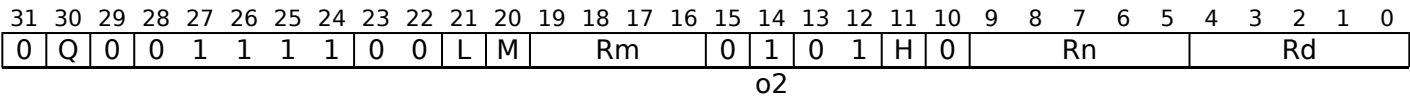
**FMLS** <V><d>, <V><n>, <Vm>.<Ts>[<index>]

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi = M;
case sz:L of
  when '0x' index = UInt(H:L);
  when '10' index = UInt(H);
  when '11' UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
boolean sub_op = (o2 == '1');
```

Vector, half-precision  
(FEAT\_FP16)



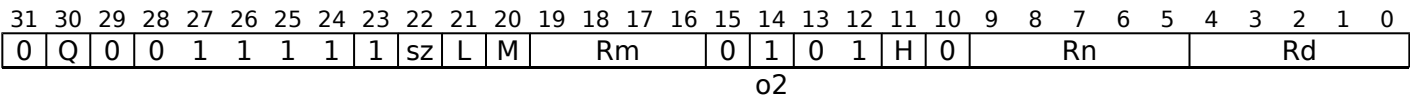
FMLS <Vd>.<T>, <Vn>.<T>, <Vm>.H[<index>]

```
if !HaveFP16Ext() then UNDEFINED;

integer idxdsize = if H == '1' then 128 else 64;
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Rd);
integer index = UInt(H:L:M);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean sub_op = (o2 == '1');
```

Vector, single-precision and double-precision



FMLS <Vd>.<T>, <Vn>.<T>, <Vm>.<Ts>[<index>]

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi = M;
case sz:L of
    when '0x' index = UInt(H:L);
    when '10' index = UInt(H);
    when '11' UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean sub_op = (o2 == '1');
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D
- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "Q:sz":

Q	sz	<T>
0	0	2S
0	1	RESERVED
1	0	4S
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> For the half-precision variant: is the name of the second SIMD&FP source register, in the range V0 to V15, encoded in the "Rm" field.

For the single-precision and double-precision variant: is the name of the second SIMD&FP source register, encoded in the "M:Rm" fields.

<Ts> Is an element size specifier, encoded in "sz":

sz	<Ts>
0	S
1	D

<index> For the half-precision variant: is the element index, in the range 0 to 7, encoded in the "H:L:M" fields.

For the single-precision and double-precision variant: is the element index, encoded in "sz:L:H":

sz	L	<index>
0	x	H:L
1	0	H
1	1	RESERVED

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(idxdsize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(esize) element1;
bits(esize) element2 = Elem[operand2, index, esize];
FPCRType fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[d] else Zeros();

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    if sub_op then element1 = FPNeg(element1);
    Elem[result, e, esize] = FPMulAdd(Elem[operand3, e, esize], element1, element2, fpcr);

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FMLS (vector)

Floating-point fused Multiply-Subtract from accumulator (vector). This instruction multiplies corresponding floating-point values in the vectors in the two source SIMD&FP registers, negates the product, adds the result to the corresponding vector element of the destination SIMD&FP register, and writes the result to the destination SIMD&FP register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

Half-precision  
(FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	1	0	Rm				0	0	0	0	1	1	Rn				Rd						
a																															

FMLS <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean sub_op = (a == '1');
```

Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	sz	1	Rm				1	1	0	0	1	1	Rn				Rd						
op																															

FMLS <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean sub_op = (op == '1');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H



For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    if sub_op then element1 = FPNeg(element1);
    Elem[result, e, esize] = FPMulAdd(Elem[operand3, e, esize], element1, element2, FPCR[]);
V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## FMLSL, FMLSL2 (by element)

Floating-point fused Multiply-Subtract Long from accumulator (by element). This instruction multiplies the negated vector elements in the first source SIMD&FP register by the specified value in the second source SIMD&FP register, and accumulates the product to the corresponding vector element of the destination SIMD&FP register. The instruction does not round the result of the multiply before the accumulation.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

In Armv8.2 and Armv8.3, this is an OPTIONAL instruction. From Armv8.4 it is mandatory for all implementations to support it.

[ID\\_AA64ISAR0\\_EL1](#).FHM indicates whether this instruction is supported.

It has encodings from 2 classes: [FMLSL](#) and [FMLSL2](#)

### FMLSL (FEAT\_FHM)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	1	0	L	M	Rm			0	1	0	0	H	0	Rn				Rd						
SZ										S																					

FMLSL <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<H>[<index>]

```
if !HaveFP16MulNoRoundingToFP32Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt('0':Rm); // Vm can only be in bottom 16 registers.
if sz == '1' then UNDEFINED;
integer index = UInt(H:L:M);

integer esize = 32;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean sub_op = (S == '1');
integer part = 0;
```

### FMLSL2 (FEAT\_FHM)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	1	0	L	M	Rm				1	1	0	0	H	0	Rn				Rd					
SZ												S																			

FMLSL2 <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<H>[<index>]

```
if !HaveFP16MulNoRoundingToFP32Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt('0':Rm); // Vm can only be in bottom 16 registers.
if sz == '1' then UNDEFINED;
integer index = UInt(H:L:M);

integer esize = 32;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean sub_op = (S == '1');
integer part = 1;
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Ta> Is an arrangement specifier, encoded in "Q":

Q	<Ta>
0	2S
1	4S

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Tb> Is an arrangement specifier, encoded in "Q":

Q	<Tb>
0	2H
1	4H

- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.
- <index> Is the element index, encoded in the "H:L:M" fields.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize DIV 2) operand1 = Vpart[n, part];
bits(128) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
bits(esize DIV 2) element1;
bits(esize DIV 2) element2 = Elem[operand2, index, esize DIV 2];

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize DIV 2];
    if sub_op then element1 = FPNeg(element1);
    Elem[result, e, esize] = FPMulAddH(Elem[operand3, e, esize], element1, element2, FPCR[]);
V[d] = result;
```

# FMLSL, FMLSL2 (vector)

Floating-point fused Multiply-Subtract Long from accumulator (vector). This instruction negates the values in the vector of one SIMD&FP register, multiplies these with the corresponding values in another vector, and accumulates the product to the corresponding vector element of the destination SIMD&FP register. The instruction does not round the result of the multiply before the accumulation.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

In Armv8.2 and Armv8.3, this is an OPTIONAL instruction. From Armv8.4 it is mandatory for all implementations to support it.

[ID\\_AA64ISAR0\\_EL1](#).FHM indicates whether this instruction is supported.

It has encodings from 2 classes: [FMLSL](#) and [FMLSL2](#)

## FMLSL (FEAT\_FHM)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	0	1	Rm				1	1	1	0	1	1	Rn				Rd						
								S		sz																					

FMLSL <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
if !HaveFP16MulNoRoundingToFP32Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz == '1' then UNDEFINED;
integer esize = 32;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean sub_op = (S == '1');
integer part = 0;
```

## FMLSL2 (FEAT\_FHM)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	0	1	Rm				1	1	0	0	1	1	Rn				Rd						
S											sz																				

FMLSL2 <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
if !HaveFP16MulNoRoundingToFP32Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz == '1' then UNDEFINED;
integer esize = 32;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean sub_op = (S == '1');
integer part = 1;
```

## Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “Q”:

Q	<Ta>
0	2S
1	4S

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “Q”:

Q	<Tb>
0	2H
1	4H

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize DIV 2) operand1 = Vpart[n, part];
bits(datasize DIV 2) operand2 = Vpart[m, part];
bits(datasize) operand3 = V[d];
bits(datasize) result;
bits(esize DIV 2) element1;
bits(esize DIV 2) element2;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize DIV 2];
    element2 = Elem[operand2, e, esize DIV 2];
    if sub_op then element1 = FPNeg(element1);
    Elem[result, e, esize] = FPMulAddH(Elem[operand3, e, esize], element1, element2, FPCR[]);
V[d] = result;
```

# FMOV (vector, immediate)

Floating-point move immediate (vector). This instruction copies an immediate floating-point constant into every element of the SIMD&FP destination register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	0	0	0	0	0	a	b	c	1	1	1	1	1	1	d	e	f	g	h	Rd				

FMOV <Vd>.<T>, #<imm>

```
if !HaveFP16Ext() then UNDEFINED;

integer rd = UInt(Rd);

integer datasize = if Q == '1' then 128 else 64;
bits(datasize) imm;

imm8 = a:b:c:d:e:f:g:h;
imm16 = imm8<7>:NOT(imm8<6>):Replicate(imm8<6>, 2):imm8<5:0>:Zeros(6);

imm = Replicate(imm16, datasize DIV 16);
```

## Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	op	0	1	1	1	1	0	0	0	0	0	a	b	c	1	1	1	1	0	1	d	e	f	g	h	Rd				
																cmode															

### Single-precision (op == 0)

FMOV <Vd>.<T>, #<imm>

### Double-precision (Q == 1 && op == 1)

```
FMOV <Vd>.2D, #<imm>

integer rd = UInt(Rd);

integer datasize = if Q == '1' then 128 else 64;
bits(datasize) imm;
bits(64) imm64;

if cmode:op == '11111' then
    // FMOV Dn,#imm is in main FP instruction set
    if Q == '0' then UNDEFINED;

imm64 = AdvSIMDExpandImm(op, cmode, a:b:c:d:e:f:g:h);
imm = Replicate(imm64, datasize DIV 64);
```

## Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in “Q”:

Q	<T>
0	4H
1	8H

For the single-precision variant: is an arrangement specifier, encoded in “Q”:

Q	<T>
0	2S
1	4S

<imm> Is a signed floating-point constant with 3-bit exponent and normalized 4 bits of precision, encoded in "a:b:c:d:e:f:g:h". For details of the range of constants available and the encoding of <imm>, see *Modified immediate constants in A64 floating-point instructions*.

Operation

```
CheckFPAdvSIMDEnabled64();  
V[rd] = imm;
```

## FMOV (register)

Floating-point Move register without conversion. This instruction copies the floating-point value in the SIMD&FP source register to the SIMD&FP destination register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1	1	1	1	0	ftype		1	0	0	0	0	0	0	1	0	0	0	0	Rn					Rd				
opc																															

### Half-precision (ftype == 11) (FEAT\_FP16)

FMOV <Hd>, <Hn>

### Single-precision (ftype == 00)

FMOV <Sd>, <Sn>

### Double-precision (ftype == 01)

FMOV <Dd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize;
case ftype of
  when '00' esize = 32;
  when '01' esize = 64;
  when '10' UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      esize = 16;
    else
      UNDEFINED;
```

## Assembler Symbols

<Dd>	Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Dn>	Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Hd>	Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Hn>	Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Sd>	Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(esize) operand = V[n];

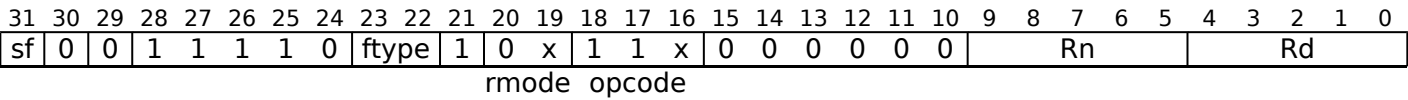
Elem[Zeros(), 0, esize] = operand;
V[d] = Zeros();
```



FMOV (general)

Floating-point Move to or from general-purpose register without conversion. This instruction transfers the contents of a SIMD&FP register to a general-purpose register, or the contents of a general-purpose register to a SIMD&FP register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



**Half-precision to 32-bit (sf == 0 && ftype == 11 && rmode == 00 && opcode == 110)**  
(FEAT\_FP16)

FMOV <Wd>, <Hn>

**Half-precision to 64-bit (sf == 1 && ftype == 11 && rmode == 00 && opcode == 110)**  
(FEAT\_FP16)

FMOV <Xd>, <Hn>

**32-bit to half-precision (sf == 0 && ftype == 11 && rmode == 00 && opcode == 111)**  
(FEAT\_FP16)

FMOV <Hd>, <Wn>

**32-bit to single-precision (sf == 0 && ftype == 00 && rmode == 00 && opcode == 111)**

FMOV <Sd>, <Wn>

**Single-precision to 32-bit (sf == 0 && ftype == 00 && rmode == 00 && opcode == 110)**

FMOV <Wd>, <Sn>

**64-bit to half-precision (sf == 1 && ftype == 11 && rmode == 00 && opcode == 111)**  
(FEAT\_FP16)

FMOV <Hd>, <Xn>

**64-bit to double-precision (sf == 1 && ftype == 01 && rmode == 00 && opcode == 111)**

FMOV <Dd>, <Xn>

**64-bit to top half of 128-bit (sf == 1 && ftype == 10 && rmode == 01 && opcode == 111)**

FMOV <Vd>.D[1], <Xn>

**Double-precision to 64-bit (sf == 1 && ftype == 01 && rmode == 00 && opcode == 110)**

FMOV <Xd>, <Dn>

**Top half of 128-bit to 64-bit (sf == 1 && ftype == 10 && rmode == 01 && opcode == 110)**

FMOV <Xd>, <Vn>.D[1]

```

integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;
FPConvOp op;
FPRounding rounding;
boolean unsigned;
integer part;

case ftype of
  when '00'
    fltsize = 32;
  when '01'
    fltsize = 64;
  when '10'
    if opcode<2:1>:rmode != '11 01' then UNDEFINED;
    fltsize = 128;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;

case opcode<2:1>:rmode of
  when '00 xx' // FCVT[NPMZ][US]
    rounding = FPDecodeRounding(rmode);
    unsigned = (opcode<0> == '1');
    op = FPConvOp_CVT_FtoI;
  when '01 00' // [US]CVTF
    rounding = FPRoundingMode(FPCR[]);
    unsigned = (opcode<0> == '1');
    op = FPConvOp_CVT_ItoF;
  when '10 00' // FCVTA[US]
    rounding = FPRounding_TIEAWAY;
    unsigned = (opcode<0> == '1');
    op = FPConvOp_CVT_FtoI;
  when '11 00' // FMOV
    if fltsize != 16 && fltsize != intsize then UNDEFINED;
    op = if opcode<0> == '1' then FPConvOp_MOV_ItoF else FPConvOp_MOV_FtoI;
    part = 0;
  when '11 01' // FMOV D[1]
    if intsize != 64 || fltsize != 128 then UNDEFINED;
    op = if opcode<0> == '1' then FPConvOp_MOV_ItoF else FPConvOp_MOV_FtoI;
    part = 1;
    fltsize = 64; // size of D[1] is 64
  when '11 11' // FJCVTZS
    if !HaveFJCVTZSExt() then UNDEFINED;
    rounding = FPRounding_ZERO;
    unsigned = (opcode<0> == '1');
    op = FPConvOp_CVT_FtoI_JS;
  otherwise
    UNDEFINED;

```

## Assembler Symbols

<Dd>	Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Hd>	Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Sd>	Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
<Vd>	Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Vn>	Is the name of the SIMD&FP source register, encoded in the "Rn" field.
<Hn>	Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Dn>	Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
```

```
FPCRType fpcr = FPCR[];
boolean merge = IsMerging(fpcr);
integer fsize = if op == FPConvOp_CVT_ItoF && merge then 128 else fltsize;
bits(fsize) fltval;
bits(intsize) intval;

case op of
  when FPConvOp_CVT_FtoI
    fltval = V[n];
    intval = FPToFixed(fltval, 0, unsigned, fpcr, rounding);
    X[d] = intval;
  when FPConvOp_CVT_ItoF
    intval = X[n];
    fltval = if merge then V[d] else Zeros();
    Elem[fltval, 0, fltsize] = FixedToFP(intval, 0, unsigned, fpcr, rounding);
    V[d] = fltval;
  when FPConvOp_MOV_FtoI
    fltval = Vpart[n, part];
    intval = ZeroExtend(fltval, intsize);
    X[d] = intval;
  when FPConvOp_MOV_ItoF
    intval = X[n];
    fltval = intval<fsize-1:0>;
    Vpart[d, part] = fltval;
  when FPConvOp_CVT_FtoI_JS
    bit Z;
    fltval = V[n];
    (intval, Z) = FPToFixedJS(fltval, fpcr, TRUE);
    PSTATE.<N,Z,C,V> = '0':Z:'00';
    X[d] = intval;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FMOV (scalar, immediate)

Floating-point move immediate (scalar). This instruction copies a floating-point immediate constant into the SIMD&FP destination register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1	1	1	1	0	f	t	y	p	e	1	imm8						1	0	0	0	0	0	0	0	Rd			

## Half-precision (ftype == 11) (FEAT\_FP16)

```
FMOV <Hd>, #<imm>
```

## Single-precision (ftype == 00)

```
FMOV <Sd>, #<imm>
```

## Double-precision (ftype == 01)

```
FMOV <Dd>, #<imm>

integer d = UInt(Rd);

integer datasize;
case ftype of
  when '00' datasize = 32;
  when '01' datasize = 64;
  when '10' UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      datasize = 16;
    else
      UNDEFINED;

bits(datasize) imm = VFPEExpandImm(imm8);
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <imm> Is a signed floating-point constant with 3-bit exponent and normalized 4 bits of precision, encoded in the "imm8" field. For details of the range of constants available and the encoding of <imm>, see [Modified immediate constants in A64 floating-point instructions](#).

## Operation

```
CheckFPAdvSIMDEnabled64();

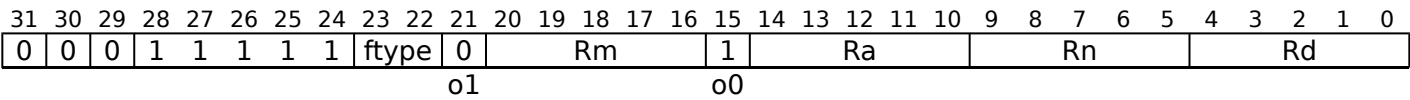
V[d] = imm;
```

# FMSUB

Floating-point Fused Multiply-Subtract (scalar). This instruction multiplies the values of the first two SIMD&FP source registers, negates the product, adds that to the value of the third SIMD&FP source register, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (FEAT\_FP16)

FMSUB <Hd>, <Hn>, <Hm>, <Ha>

## Single-precision (ftype == 00)

FMSUB <Sd>, <Sn>, <Sm>, <Sa>

## Double-precision (ftype == 01)

FMSUB <Dd>, <Dn>, <Dm>, <Da>

```
integer d = UInt(Rd);
integer a = UInt(Ra);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer esize;
case ftype of
  when '00' esize = 32;
  when '01' esize = 64;
  when '10' UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      esize = 16;
    else
      UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the first SIMD&FP source register holding the multiplicand, encoded in the "Rn" field.
- <Dm> Is the 64-bit name of the second SIMD&FP source register holding the multiplier, encoded in the "Rm" field.
- <Da> Is the 64-bit name of the third SIMD&FP source register holding the minuend, encoded in the "Ra" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register holding the multiplicand, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register holding the multiplier, encoded in the "Rm" field.

<Ha>	Is the 16-bit name of the third SIMD&FP source register holding the minuend, encoded in the "Ra" field.
<Sd>	Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the first SIMD&FP source register holding the multiplicand, encoded in the "Rn" field.
<Sm>	Is the 32-bit name of the second SIMD&FP source register holding the multiplier, encoded in the "Rm" field.
<Sa>	Is the 32-bit name of the third SIMD&FP source register holding the minuend, encoded in the "Ra" field.

## Operation

```

CheckFPAdvSIMDEnabled64();

bits(esize) operandA = V[a];
bits(esize) operand1 = V[n];
bits(esize) operand2 = V[m];

FPCRTYPE fpcr = FPCR[];
boolean merge = IsMerging(fpcr);
bits(128) result = if merge then V[a] else Zeros();

operand1 = FPNeg(operand1);
Elem[result, 0, esize] = FPMulAdd(operandA, operand1, operand2, fpcr);

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## FMUL (by element)

Floating-point Multiply (by element). This instruction multiplies the vector elements in the first source SIMD&FP register by the specified value in the second source SIMD&FP register, places the results in a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are floating-point values.

This instruction can generate a floating-point exception. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#) or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar, half-precision](#) , [Scalar, single-precision and double-precision](#) , [Vector, half-precision](#) and [Vector, single-precision and double-precision](#)

### Scalar, half-precision

(FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	0	0	L	M	Rm				1	0	0	1	H	0	Rn				Rd					
U																															

**FMUL** <Hd>, <Hn>, <Vm>.H[<index>]

```
if !HaveFP16Ext() then UNDEFINED;
```

```
integer idxdsize = if H == '1' then 128 else 64;
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Rd);
integer index = UInt(H:L:M);

integer esize = 16;
integer datasize = esize;
integer elements = 1;
boolean mulx_op = (U == '1');
```

### Scalar, single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	1	sz	L	M	Rm				1	0	0	1	H	0	Rn				Rd					
U																															

**FMUL** <V><d>, <V><n>, <Vm>.<Ts>[<index>]

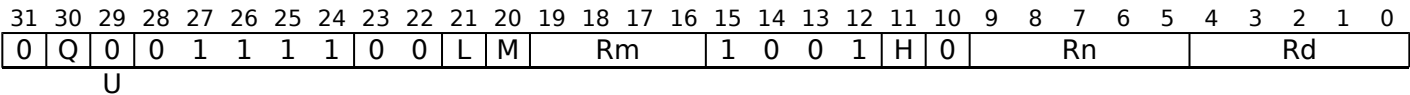
```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi = M;
case sz:L of
  when '0x' index = UInt(H:L);
  when '10' index = UInt(H);
  when '11' UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
boolean mulx_op = (U == '1');
```



Vector, half-precision  
(FEAT\_FP16)



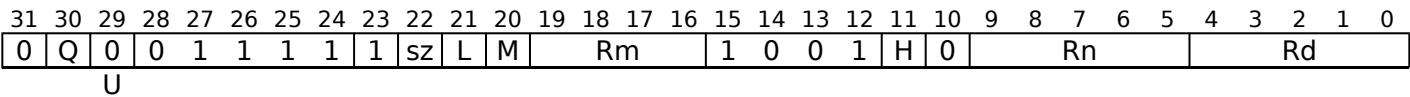
FMUL <Vd>.<T>, <Vn>.<T>, <Vm>.H[<index>]

```
if !HaveFP16Ext() then UNDEFINED;

integer idxdsize = if H == '1' then 128 else 64;
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Rd);
integer index = UInt(H:L:M);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean mulx_op = (U == '1');
```

Vector, single-precision and double-precision



FMUL <Vd>.<T>, <Vn>.<T>, <Vm>.<Ts>[<index>]

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi = M;
case sz:L of
    when '0x' index = UInt(H:L);
    when '10' index = UInt(H);
    when '11' UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean mulx_op = (U == '1');
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D
- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "Q:sz":

Q	sz	<T>
0	0	2S
0	1	RESERVED
1	0	4S
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> For the half-precision variant: is the name of the second SIMD&FP source register, in the range V0 to V15, encoded in the "Rm" field.

For the single-precision and double-precision variant: is the name of the second SIMD&FP source register, encoded in the "M:Rm" fields.

<Ts> Is an element size specifier, encoded in "sz":

sz	<Ts>
0	S
1	D

<index> For the half-precision variant: is the element index, in the range 0 to 7, encoded in the "H:L:M" fields.

For the single-precision and double-precision variant: is the element index, encoded in "sz:L:H":

sz	L	<index>
0	x	H:L
1	0	H
1	1	RESERVED

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(idxsizesize) operand2 = V[m];
bits(esize) element1;
bits(esize) element2 = Elem[operand2, index, esize];
FPCRTType fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[n] else Zeros();

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    if mulx_op then
        Elem[result, e, esize] = FPMu1X(element1, element2, fpcr);
    else
        Elem[result, e, esize] = FPMu1(element1, element2, fpcr);
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FMUL (vector)

Floating-point Multiply (vector). This instruction multiplies corresponding floating-point values in the vectors in the two source SIMD&FP registers, places the result in a vector, and writes the vector to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	1	0	Rm				0	0	0	1	1	1	Rn				Rd						

FMUL <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

## Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	sz	1	Rm				1	1	0	1	1	1	Rn				Rd						

FMUL <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

## Assembler Symbols

- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T>

For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = FPMul(element1, element2, FPCR[]);

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

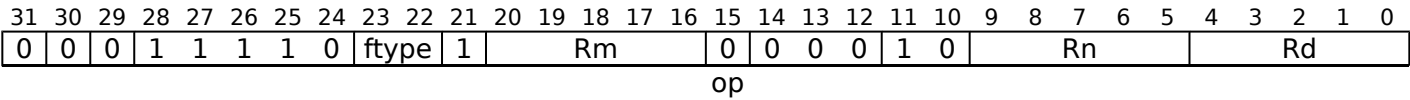
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FMUL (scalar)

Floating-point Multiply (scalar). This instruction multiplies the floating-point values of the two source SIMD&FP registers, and writes the result to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (FEAT\_FP16)

FMUL <Hd>, <Hn>, <Hm>

## Single-precision (ftype == 00)

FMUL <Sd>, <Sn>, <Sm>

## Double-precision (ftype == 01)

FMUL <Dd>, <Dn>, <Dm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer esize;
case ftype of
    when '00' esize = 32;
    when '01' esize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            esize = 16;
        else
            UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Dm> Is the 64-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Sm> Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(esize) operand1 = V[n];
bits(esize) operand2 = V[m];

FPCRTYPE fpcr = FPCR[];
boolean merge = IsMerging(fpcr);
bits(128) result = if merge then V[n] else Zeros();

bits(esize) product = FPMul(operand1, operand2, fpcr);
Elem[result, 0, esize] = product;

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## FMULX (by element)

Floating-point Multiply extended (by element). This instruction multiplies the floating-point values in the vector elements in the first source SIMD&FP register by the specified floating-point value in the second source SIMD&FP register, places the results in a vector, and writes the vector to the destination SIMD&FP register.

If one value is zero and the other value is infinite, the result is 2.0. In this case, the result is negative if only one of the values is negative, otherwise the result is positive.

This instruction can generate a floating-point exception. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#) or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar, half-precision](#) , [Scalar, single-precision and double-precision](#) , [Vector, half-precision](#) and [Vector, single-precision and double-precision](#)

### Scalar, half-precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	1	0	0	L	M				Rm		1	0	0	1	H	0								Rd	
U																															

**FMULX** <Hd>, <Hn>, <Vm>.H[<index>]

```
if !HaveFP16Ext() then UNDEFINED;
```

```
integer idxdsize = if H == '1' then 128 else 64;
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Rd);
integer index = UInt(H:L:M);

integer esize = 16;
integer datasize = esize;
integer elements = 1;
boolean mulx_op = (U == '1');
```

### Scalar, single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	1	1	sz	L	M				Rm		1	0	0	1	H	0								Rd	
U																															

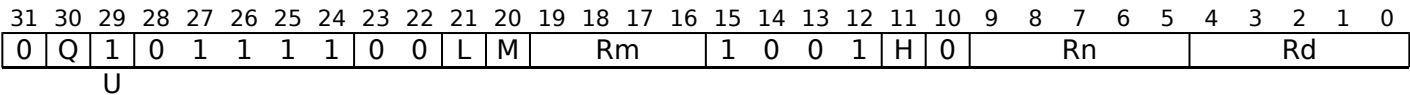
**FMULX** <V><d>, <V><n>, <Vm>.<Ts>[<index>]

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi = M;
case sz:L of
  when '0x' index = UInt(H:L);
  when '10' index = UInt(H);
  when '11' UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
boolean mulx_op = (U == '1');
```

Vector, half-precision  
(FEAT\_FP16)



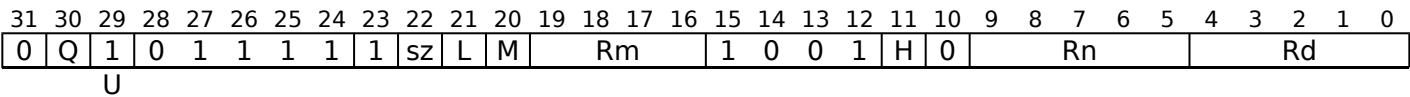
FMULX <Vd>.<T>, <Vn>.<T>, <Vm>.H[<index>]

```
if !HaveFP16Ext() then UNDEFINED;

integer idxdsize = if H == '1' then 128 else 64;
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Rd);
integer index = UInt(H:L:M);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean mulx_op = (U == '1');
```

Vector, single-precision and double-precision



FMULX <Vd>.<T>, <Vn>.<T>, <Vm>.<Ts>[<index>]

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi = M;
case sz:L of
    when '0x' index = UInt(H:L);
    when '10' index = UInt(H);
    when '11' UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean mulx_op = (U == '1');
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D
- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.



<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "Q:sz":

Q	sz	<T>
0	0	2S
0	1	RESERVED
1	0	4S
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> For the half-precision variant: is the name of the second SIMD&FP source register, in the range V0 to V15, encoded in the "Rm" field.

For the single-precision and double-precision variant: is the name of the second SIMD&FP source register, encoded in the "M:Rm" fields.

<Ts> Is an element size specifier, encoded in "sz":

sz	<Ts>
0	S
1	D

<index> For the half-precision variant: is the element index, in the range 0 to 7, encoded in the "H:L:M" fields.

For the single-precision and double-precision variant: is the element index, encoded in "sz:L:H":

sz	L	<index>
0	x	H:L
1	0	H
1	1	RESERVED

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(idxsized) operand2 = V[m];
bits(esize) element1;
bits(esize) element2 = Elem[operand2, index, esize];
FPCRTYPE fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[n] else Zeros();

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    if mulx_op then
        Elem[result, e, esize] = FPMuLX(element1, element2, fpcr);
    else
        Elem[result, e, esize] = FPMuL(element1, element2, fpcr);
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## FMULX

Floating-point Multiply extended. This instruction multiplies corresponding floating-point values in the vectors of the two source SIMD&FP registers, places the resulting floating-point values in a vector, and writes the vector to the destination SIMD&FP register.

If one value is zero and the other value is infinite, the result is 2.0. In this case, the result is negative if only one of the values is negative, otherwise the result is positive.

This instruction can generate a floating-point exception. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

### Scalar half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	1	0	Rm				0	0	0	1	1	1	Rn				Rd						

FMULX <Hd>, <Hn>, <Hm>

```
if !HaveFP16Ext() then UNDEFINED;
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = esize;
integer elements = 1;
```

### Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	sz	1	Rm				1	1	0	1	1	1	Rn				Rd						

FMULX <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
```

### Vector half precision (FEAT\_FP16)

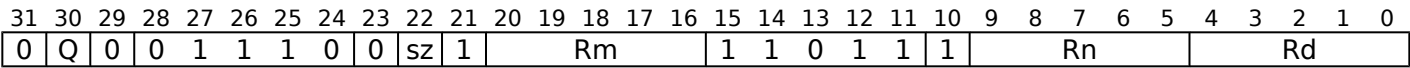
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	1	1	1	0	0	1	0	Rm				0	0	0	1	1	1	Rn				Rd						

FMULX <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Vector single-precision and double-precision



FMULX <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];

bits(esize) element1;
bits(esize) element2;
FPCRType fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[n] else Zeros();

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = FPMuLX(element1, element2, fpcr);
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

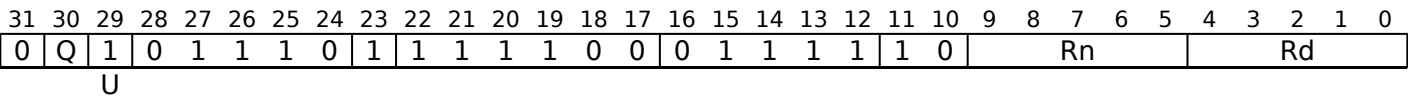
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FNEG (vector)

Floating-point Negate (vector). This instruction negates the value of each vector element in the source SIMD&FP register, writes the result to a vector, and writes the vector to the destination SIMD&FP register.  
Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: Half-precision and Single-precision and double-precision

Half-precision  
(FEAT\_FP16)



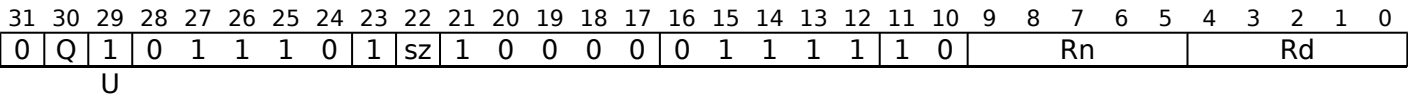
FNEG <Vd>.<T>, <Vn>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean neg = (U == '1');
```

Single-precision and double-precision



FNEG <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean neg = (U == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    if neg then
        element = FPNeg(element);
    else
        element = FPAbs(element);
    Elem[result, e, esize] = element;

V[d] = result;

```

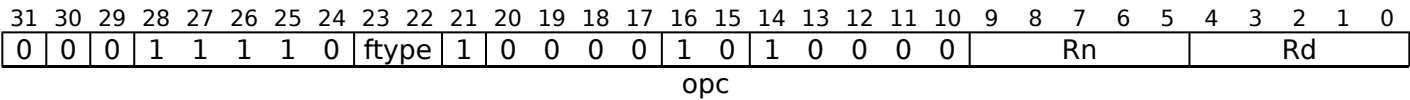
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FNEG (scalar)

Floating-point Negate (scalar). This instruction negates the value in the SIMD&FP source register and writes the result to the SIMD&FP destination register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (FEAT\_FP16)

FNEG <Hd>, <Hn>

## Single-precision (ftype == 00)

FNEG <Sd>, <Sn>

## Double-precision (ftype == 01)

FNEG <Dd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize;
case ftype of
  when '00' esize = 32;
  when '01' esize = 64;
  when '10' UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      esize = 16;
    else
      UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();

FPCRType fpcr = FPCR[];
boolean merge = IsMerging(fpcr);
bits(128) result = if merge then V[d] else Zeros();

bits(esize) operand = V[n];

Elem[result, 0, esize] = FPNeg(operand);
V[d] = result;
```



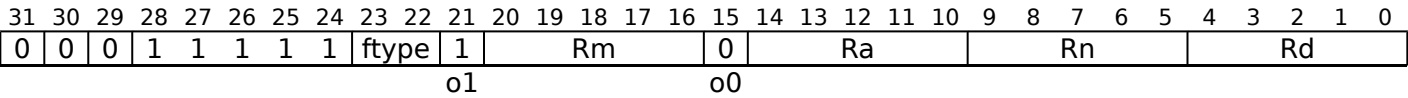


# FNMADD

Floating-point Negated fused Multiply-Add (scalar). This instruction multiplies the values of the first two SIMD&FP source registers, negates the product, subtracts the value of the third SIMD&FP source register, and writes the result to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Half-precision (ftype == 11)  
(FEAT\_FP16)

FNMADD <Hd>, <Hn>, <Hm>, <Ha>

Single-precision (ftype == 00)

FNMADD <Sd>, <Sn>, <Sm>, <Sa>

Double-precision (ftype == 01)

FNMADD <Dd>, <Dn>, <Dm>, <Da>

```
integer d = UInt(Rd);
integer a = UInt(Ra);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer esize;
case ftype of
  when '00' esize = 32;
  when '01' esize = 64;
  when '10' UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      esize = 16;
    else
      UNDEFINED;
```

## Assembler Symbols

- <Dd>

Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn>

Is the 64-bit name of the first SIMD&FP source register holding the multiplicand, encoded in the "Rn" field.
- <Dm>

Is the 64-bit name of the second SIMD&FP source register holding the multiplier, encoded in the "Rm" field.
- <Da>

Is the 64-bit name of the third SIMD&FP source register holding the addend, encoded in the "Ra" field.
- <Hd>

Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn>

Is the 16-bit name of the first SIMD&FP source register holding the multiplicand, encoded in the "Rn" field.
- <Hm>

Is the 16-bit name of the second SIMD&FP source register holding the multiplier, encoded in the "Rm" field.
- <Ha>

Is the 16-bit name of the third SIMD&FP source register holding the addend, encoded in the "Ra" field.

<Sd>	Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the first SIMD&FP source register holding the multiplicand, encoded in the "Rn" field.
<Sm>	Is the 32-bit name of the second SIMD&FP source register holding the multiplier, encoded in the "Rm" field.
<Sa>	Is the 32-bit name of the third SIMD&FP source register holding the addend, encoded in the "Ra" field.

## Operation

```

CheckFPAdvSIMDEnabled64();

bits(esize) operanda = V[a];
bits(esize) operand1 = V[n];
bits(esize) operand2 = V[m];

FPCRTYPE fpcr = FPCR[];
boolean merge = IsMerging(fpcr);
bits(128) result = if merge then V[a] else Zeros();

operanda = FPNeg(operanda);
operand1 = FPNeg(operand1);
Elem[result, 0, esize] = FPMulAdd(operanda, operand1, operand2, fpcr);

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

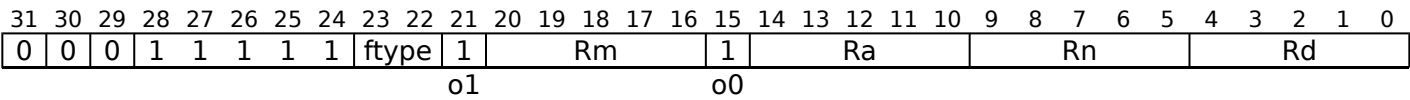
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FNMSUB

Floating-point Negated fused Multiply-Subtract (scalar). This instruction multiplies the values of the first two SIMD&FP source registers, subtracts the value of the third SIMD&FP source register, and writes the result to the destination SIMD&FP register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (FEAT\_FP16)

FNMSUB <Hd>, <Hn>, <Hm>, <Ha>

## Single-precision (ftype == 00)

FNMSUB <Sd>, <Sn>, <Sm>, <Sa>

## Double-precision (ftype == 01)

FNMSUB <Dd>, <Dn>, <Dm>, <Da>

```
integer d = UInt(Rd);
integer a = UInt(Ra);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer esize;
case ftype of
    when '00' esize = 32;
    when '01' esize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            esize = 16;
        else
            UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the first SIMD&FP source register holding the multiplicand, encoded in the "Rn" field.
- <Dm> Is the 64-bit name of the second SIMD&FP source register holding the multiplier, encoded in the "Rm" field.
- <Da> Is the 64-bit name of the third SIMD&FP source register holding the minuend, encoded in the "Ra" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register holding the multiplicand, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register holding the multiplier, encoded in the "Rm" field.

<Ha>	Is the 16-bit name of the third SIMD&FP source register holding the minuend, encoded in the "Ra" field.
<Sd>	Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the first SIMD&FP source register holding the multiplicand, encoded in the "Rn" field.
<Sm>	Is the 32-bit name of the second SIMD&FP source register holding the multiplier, encoded in the "Rm" field.
<Sa>	Is the 32-bit name of the third SIMD&FP source register holding the minuend, encoded in the "Ra" field.

## Operation

```

CheckFPAdvSIMDEnabled64();

bits(esize) operanda = V[a];
bits(esize) operand1 = V[n];
bits(esize) operand2 = V[m];

FPCRTYPE fpcr = FPCR[];
boolean merge = IsMerging(fpcr);
bits(128) result = if merge then V[a] else Zeros();

operanda = FPNeg(operanda);
Elem[result, 0, esize] = FPMulAdd(operanda, operand1, operand2, fpcr);

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

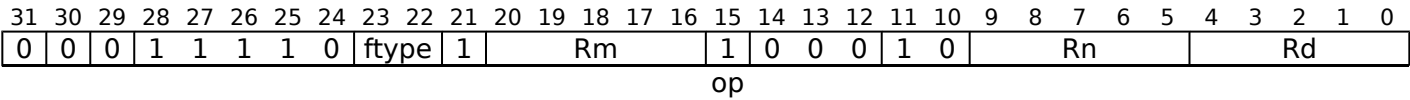
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FNMUL (scalar)

Floating-point Multiply-Negate (scalar). This instruction multiplies the floating-point values of the two source SIMD&FP registers, and writes the negation of the result to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (FEAT\_FP16)

FNMUL <Hd>, <Hn>, <Hm>

## Single-precision (ftype == 00)

FNMUL <Sd>, <Sn>, <Sm>

## Double-precision (ftype == 01)

FNMUL <Dd>, <Dn>, <Dm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer esize;
case ftype of
    when '00' esize = 32;
    when '01' esize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            esize = 16;
        else
            UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Dm> Is the 64-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Sm> Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(esize) operand1 = V[n];
bits(esize) operand2 = V[m];

FPCRType fpcr = FPCR[];
boolean merge = IsMerging(fpcr);
bits(128) result = if merge then V[n] else Zeros();

bits(esize) product = FPMul(operand1, operand2, fpcr);
product = FPNeg(product);
Elem[result, 0, esize] = product;

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## FRECPE

Floating-point Reciprocal Estimate. This instruction finds an approximate reciprocal estimate for each vector element in the source SIMD&FP register, places the result in a vector, and writes the vector to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#) or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

### Scalar half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	1	1	1	1	1	0	0	1	1	1	0	1	1	0	Rn				Rd					

FRECPE <Hd>, <Hn>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;
```

### Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	1	sz	1	0	0	0	0	1	1	1	0	1	1	0	Rn				Rd					

FRECPE <V><d>, <V><n>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
```

### Vector half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	1	1	1	1	0	0	1	1	1	0	1	1	0	Rn				Rd					

FRECPE <Vd>.<T>, <Vn>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Vector single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	sz	1	0	0	0	0	1	1	1	0	1	1	0	Rn				Rd					

FRECPE <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];

FPCRTType fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[d] else Zeros();
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPRecipEstimate(element, FPCR[]);

V[d] = result;
```





## FRECPS

Floating-point Reciprocal Step. This instruction multiplies the corresponding floating-point values in the vectors of the two source SIMD&FP registers, subtracts each of the products from 2.0, places the resulting floating-point values in a vector, and writes the vector to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#), [Scalar single-precision and double-precision](#), [Vector half precision](#) and [Vector single-precision and double-precision](#)

### Scalar half precision

(FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	1	0	Rm				0	0	1	1	1	1	Rn				Rd						

FRECPS <Hd>, <Hn>, <Hm>

```
if !HaveFP16Ext() then UNDEFINED;
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = esize;
integer elements = 1;
```

### Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	sz	1	Rm				1	1	1	1	1	1	Rn				Rd						

FRECPS <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
```

### Vector half precision

(FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	1	0	Rm				0	0	1	1	1	1	Rn				Rd						

FRECPS <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Vector single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	sz	1	Rm					1	1	1	1	1	1	Rn					Rd				

FRECPS <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];

bits(esize) element1;
bits(esize) element2;
FPCRType fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[n] else Zeros();

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = FPRecipStepFused(element1, element2);

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FRECPX

Floating-point Reciprocal exponent (scalar). This instruction finds an approximate reciprocal exponent for each vector element in the source SIMD&FP register, places the result in a vector, and writes the vector to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	1	1	1	1	1	0	0	1	1	1	1	1	1	0	Rn					Rd				

FRECPX <Hd>, <Hn>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;
```

## Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	1	sz	1	0	0	0	0	1	1	1	1	1	1	0	Rn					Rd				

FRECPX <V><d>, <V><n>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
```

## Assembler Symbols

- <Hd>

Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn>

Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <V>

Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D
- <d>

Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n>

Is the number of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];

FPCRType fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[d] else Zeros();
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPreCPX(element, fpcr);

V[d] = result;
```

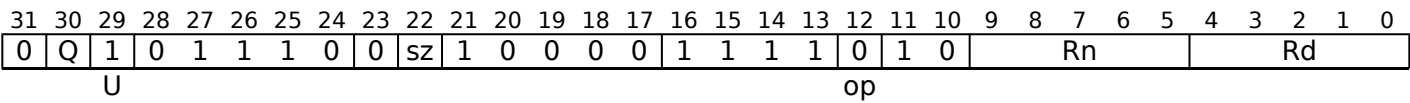
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FRINT32X (vector)

Floating-point Round to 32-bit Integer, using current rounding mode (vector). This instruction rounds a vector of floating-point values in the SIMD&FP source register to integral floating-point values that fit into a 32-bit integer size using the rounding mode that is determined by the *FPCR*, and writes the result to the SIMD&FP destination register. A zero input returns a zero result with the same sign. When one of the result values is not numerically equal to the corresponding input value, an Inexact exception is raised. When an input is infinite, NaN or out-of-range, the instruction returns for the corresponding result value the most negative integer representable in the destination size, and an Invalid Operation floating-point exception is raised. A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*. Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

Vector single-precision and double-precision (FEAT\_FRINTTS)



FRINT32X <Vd>.<T>, <Vn>.<T>

```
if !HaveFrintExt() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
integer intsize = if op == '0' then 32 else 64;
FPRounding rounding = if U == '0' then FPRounding_ZERO else FPRoundingMode(FPCR[]);
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPRoundIntN(element, FPCR[], rounding, intsize);

V[d] = result;
```





# FRINT32X (scalar)

Floating-point Round to 32-bit Integer, using current rounding mode (scalar). This instruction rounds a floating-point value in the SIMD&FP source register to an integral floating-point value that fits into a 32-bit integer size using the rounding mode that is determined by the [FPCR](#), and writes the result to the SIMD&FP destination register.

A zero input returns a zero result with the same sign. When the result value is not numerically equal to the input value, an Inexact exception is raised. When the input is infinite, NaN or out-of-range, the instruction returns {for the corresponding result value} the most negative integer representable in the destination size, and an Invalid Operation floating-point exception is raised.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

## Floating-point (FEAT\_FRINTTS)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1	1	1	1	0	0	x	1	0	1	0	0	0	1	1	0	0	0	0	Rn				Rd					
ftype										op																					

### Single-precision (ftype == 00)

FRINT32X <Sd>, <Sn>

### Double-precision (ftype == 01)

FRINT32X <Dd>, <Dn>

```
if !HaveFrintExt() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize;
case ftype of
  when '00' esize = 32;
  when '01' esize = 64;
  when '1x' UNDEFINED;

FPRounding rounding = FPRoundingMode(FPCR[]);
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
FPCRTYPE fpcr = FPCR[];  
boolean merge = IsMerging(fpcr);  
bits(128) result = if merge then V[d] else Zeros();  
bits(esize) operand = V[n];  
  
Elem[result, 0, esize] = FPRoundIntN(operand, fpcr, rounding, 32);  
  
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FRINT32Z (vector)

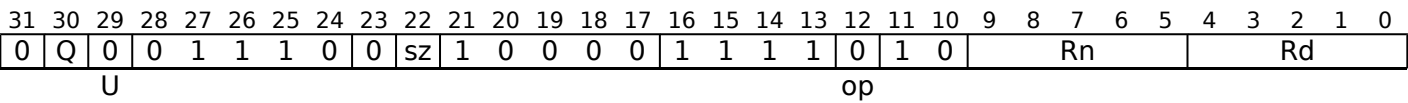
Floating-point Round to 32-bit Integer toward Zero (vector). This instruction rounds a vector of floating-point values in the SIMD&FP source register to integral floating-point values that fit into a 32-bit integer size using the Round towards Zero rounding mode, and writes the result to the SIMD&FP destination register.

A zero input returns a zero result with the same sign. When one of the result values is not numerically equal to the corresponding input value, an Inexact exception is raised. When an input is infinite, NaN or out-of-range, the instruction returns for the corresponding result value the most negative integer representable in the destination size, and an Invalid Operation floating-point exception is raised.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

Vector single-precision and double-precision (FEAT\_FrintTTS)



FRINT32Z <Vd>.<T>, <Vn>.<T>

```
if !HaveFrintExt() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
integer intsize = if op == '0' then 32 else 64;
FPRounding rounding = if U == '0' then FPRounding_ZERO else FPRoundingMode(FPCR[]);
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPRoundIntN(element, FPCR[], rounding, intsize);

V[d] = result;
```



# FRINT32Z (scalar)

Floating-point Round to 32-bit Integer toward Zero (scalar). This instruction rounds a floating-point value in the SIMD&FP source register to an integral floating-point value that fits into a 32-bit integer size using the Round towards Zero rounding mode, and writes the result to the SIMD&FP destination register.

A zero input returns a zero result with the same sign. When the result value is not numerically equal to the {corresponding} input value, an Inexact exception is raised. When the input is infinite, NaN or out-of-range, the instruction returns {for the corresponding result value} the most negative integer representable in the destination size, and an Invalid Operation floating-point exception is raised.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

## Floating-point (FEAT\_FrintTS)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1	1	1	1	0	0	x	1	0	1	0	0	0	0	1	0	0	0	0	Rn				Rd					
ftype										op																					

### Single-precision (ftype == 00)

FRINT32Z <Sd>, <Sn>

### Double-precision (ftype == 01)

FRINT32Z <Dd>, <Dn>

```
if !HaveFrintExt() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize;
case ftype of
  when '00' esize = 32;
  when '01' esize = 64;
  when '1x' UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();

FPCRTYPE fpcr = FPCR[];
boolean merge = IsMerging(fpcr);
bits(128) result = if merge then V[d] else Zeros();
bits(esize) operand = V[n];

Elem[result, 0, esize] = FPRoundIntN(operand, fpcr, FPRounding_ZERO, 32);

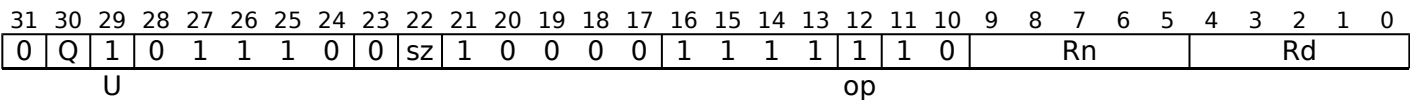
V[d] = result;
```



FRINT64X (vector)

Floating-point Round to 64-bit Integer, using current rounding mode (vector). This instruction rounds a vector of floating-point values in the SIMD&FP source register to integral floating-point values that fit into a 64-bit integer size using the rounding mode that is determined by the *FPCR*, and writes the result to the SIMD&FP destination register. A zero input returns a zero result with the same sign. When one of the result values is not numerically equal to the corresponding input value, an Inexact exception is raised. When an input is infinite, NaN or out-of-range, the instruction returns for the corresponding result value the most negative integer representable in the destination size, and an Invalid Operation floating-point exception is raised. A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*. Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

Vector single-precision and double-precision (FEAT\_FRINTTS)



FRINT64X <Vd>.<T>, <Vn>.<T>

```
if !HaveFrintExt() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
integer intsize = if op == '0' then 32 else 64;
FPRounding rounding = if U == '0' then FPRounding_ZERO else FPRoundingMode(FPCR[]);
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPRoundIntN(element, FPCR[], rounding, intsize);

V[d] = result;
```





# FRINT64X (scalar)

Floating-point Round to 64-bit Integer, using current rounding mode (scalar). This instruction rounds a floating-point value in the SIMD&FP source register to an integral floating-point value that fits into a 64-bit integer size using the rounding mode that is determined by the [FPCR](#), and writes the result to the SIMD&FP destination register.

A zero input returns a zero result with the same sign. When the result value is not numerically equal to the input value, an Inexact exception is raised. When the input is infinite, NaN or out-of-range, the instruction returns {for the corresponding result value} the most negative integer representable in the destination size, and an Invalid Operation floating-point exception is raised.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

## Floating-point (FEAT\_FrintTS)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1	1	1	1	0	0	x	1	0	1	0	0	1	1	1	0	0	0	0	Rn				Rd					
ftype										op																					

### Single-precision (ftype == 00)

FRINT64X <Sd>, <Sn>

### Double-precision (ftype == 01)

FRINT64X <Dd>, <Dn>

```
if !HaveFrintExt() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize;
case ftype of
    when '00' esize = 32;
    when '01' esize = 64;
    when '1x' UNDEFINED;

FPRounding rounding = FPRoundingMode(FPCR[]);
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
FPCRTYPE fpcr = FPCR[];  
boolean merge = IsMerging(fpcr);  
bits(128) result = if merge then V[d] else Zeros();  
bits(esize) operand = V[n];  
  
Elem[result, 0, esize] = FPRoundIntN(operand, fpcr, rounding, 64);  
  
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FRINT64Z (vector)

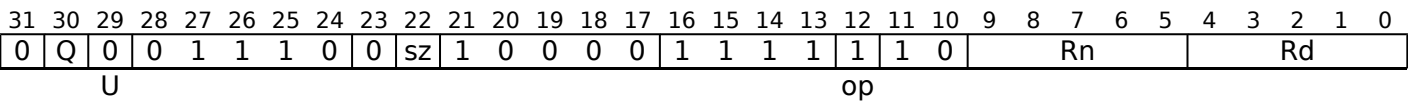
Floating-point Round to 64-bit Integer toward Zero (vector). This instruction rounds a vector of floating-point values in the SIMD&FP source register to integral floating-point values that fit into a 64-bit integer size using the Round towards Zero rounding mode, and writes the result to the SIMD&FP destination register.

A zero input returns a zero result with the same sign. When one of the result values is not numerically equal to the corresponding input value, an Inexact exception is raised. When an input is infinite, NaN or out-of-range, the instruction returns for the corresponding result value the most negative integer representable in the destination size, and an Invalid Operation floating-point exception is raised.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

Vector single-precision and double-precision (FEAT\_FrintTTS)



FRINT64Z <Vd>.<T>, <Vn>.<T>

```
if !HaveFrintExt() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
integer intsize = if op == '0' then 32 else 64;
FPRounding rounding = if U == '0' then FPRounding_ZERO else FPRoundingMode(FPCR[]);
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPRoundIntN(element, FPCR[], rounding, intsize);

V[d] = result;
```



# FRINT64Z (scalar)

Floating-point Round to 64-bit Integer toward Zero (scalar). This instruction rounds a floating-point value in the SIMD&FP source register to an integral floating-point value that fits into a 64-bit integer size using the Round towards Zero rounding mode, and writes the result to the SIMD&FP destination register.

A zero input returns a zero result with the same sign. When the result value is not numerically equal to the {corresponding} input value, an Inexact exception is raised. When the input is infinite, NaN or out-of-range, the instruction returns {for the corresponding result value} the most negative integer representable in the destination size, and an Invalid Operation floating-point exception is raised.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

## Floating-point (FEAT\_FrintTS)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1	1	1	1	0	0	x	1	0	1	0	0	1	0	1	0	0	0	0	Rn				Rd					
ftype										op																					

### Single-precision (ftype == 00)

FRINT64Z <Sd>, <Sn>

### Double-precision (ftype == 01)

FRINT64Z <Dd>, <Dn>

```
if !HaveFrintExt() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize;
case ftype of
  when '00' esize = 32;
  when '01' esize = 64;
  when '1x' UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();

FPCRTyp fpcr = FPCR[];
boolean merge = IsMerging(fpcr);
bits(128) result = if merge then V[d] else Zeros();
bits(esize) operand = V[n];

Elem[result, 0, esize] = FPRoundIntN(operand, fpcr, FPRounding_ZERO, 64);

V[d] = result;
```



# FRINTA (vector)

Floating-point Round to Integral, to nearest with ties to Away (vector). This instruction rounds a vector of floating-point values in the SIMD&FP source register to integral floating-point values of the same size using the Round to Nearest with Ties to Away rounding mode, and writes the result to the SIMD&FP destination register.

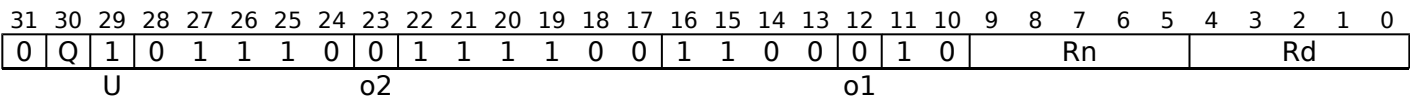
A zero input gives a zero result with the same sign, an infinite input gives an infinite result with the same sign, and a NaN is propagated as for normal arithmetic.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (FEAT\_FP16)



FRINTA <Vd>.<T>, <Vn>.<T>

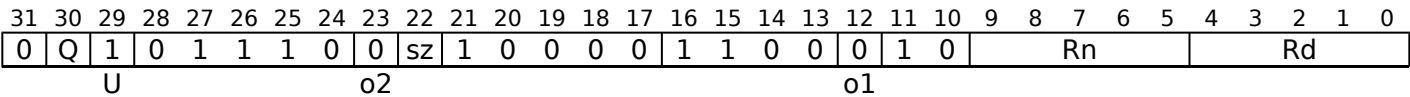
```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean exact = FALSE;
FPRounding rounding;
case U:o1:o2 of
    when '0xx' rounding = FPDecodeRounding(o1:o2);
    when '100' rounding = FPRounding_TIEAWAY;
    when '101' UNDEFINED;
    when '110' rounding = FPRoundingMode(FPCR[]); exact = TRUE;
    when '111' rounding = FPRoundingMode(FPCR[]);
```

## Single-precision and double-precision



FRINTA <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean exact = FALSE;
FPRounding rounding;
case U:o1:o2 of
  when '0xx' rounding = FPDecodeRounding(o1:o2);
  when '100' rounding = FPRounding_TIEAWAY;
  when '101' UNDEFINED;
  when '110' rounding = FPRoundingMode(FPCR[]); exact = TRUE;
  when '111' rounding = FPRoundingMode(FPCR[]);
```

### Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

### Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
  element = Elem[operand, e, esize];
  Elem[result, e, esize] = FPRoundInt(element, FPCR[], rounding, exact);
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



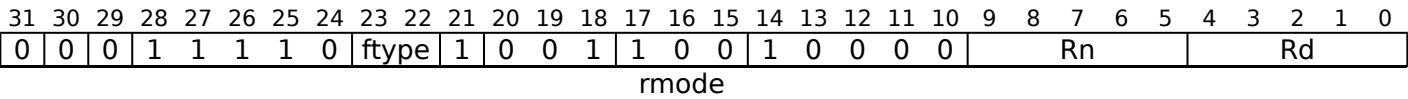
# FRINTA (scalar)

Floating-point Round to Integral, to nearest with ties to Away (scalar). This instruction rounds a floating-point value in the SIMD&FP source register to an integral floating-point value of the same size using the Round to Nearest with Ties to Away rounding mode, and writes the result to the SIMD&FP destination register.

A zero input gives a zero result with the same sign, an infinite input gives an infinite result with the same sign, and a NaN is propagated as for normal arithmetic.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (FEAT\_FP16)

FRINTA <Hd>, <Hn>

## Single-precision (ftype == 00)

FRINTA <Sd>, <Sn>

## Double-precision (ftype == 01)

FRINTA <Dd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize;
case ftype of
    when '00' esize = 32;
    when '01' esize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            esize = 16;
        else
            UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
FPCRTYPE fpcr = FPCR[];  
boolean merge = IsMerging(fpcr);  
bits(128) result = if merge then V[d] else Zeros();  
bits(esize) operand = V[n];  
  
Elem[result, 0, esize] = FPRoundInt(operand, fpcr, FPRounding_TIEAWAY, FALSE);  
  
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FRINTI (vector)

Floating-point Round to Integral, using current rounding mode (vector). This instruction rounds a vector of floating-point values in the SIMD&FP source register to integral floating-point values of the same size using the rounding mode that is determined by the [FPCR](#), and writes the result to the SIMD&FP destination register.

A zero input gives a zero result with the same sign, an infinite input gives an infinite result with the same sign, and a NaN is propagated as for normal arithmetic.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	1	1	1	1	0	0	1	1	0	0	1	1	0	Rn				Rd					
U								o2				o1																			

FRINTI <Vd>.<T>, <Vn>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean exact = FALSE;
FPRounding rounding;
case U:o1:o2 of
    when '0xx' rounding = FPDecodeRounding(o1:o2);
    when '100' rounding = FPRounding_TIEAWAY;
    when '101' UNDEFINED;
    when '110' rounding = FPRoundingMode(FPCR[]); exact = TRUE;
    when '111' rounding = FPRoundingMode(FPCR[]);
```

## Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	sz	1	0	0	0	0	1	1	0	0	1	1	0	Rn				Rd					
U								o2				o1																			

FRINTI <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean exact = FALSE;
FPRounding rounding;
case U:o1:o2 of
  when '0xx' rounding = FPDecodeRounding(o1:o2);
  when '100' rounding = FPRounding_TIEAWAY;
  when '101' UNDEFINED;
  when '110' rounding = FPRoundingMode(FPCR[]); exact = TRUE;
  when '111' rounding = FPRoundingMode(FPCR[]);
```

### Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

### Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
  element = Elem[operand, e, esize];
  Elem[result, e, esize] = FPRoundInt(element, FPCR[], rounding, exact);
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

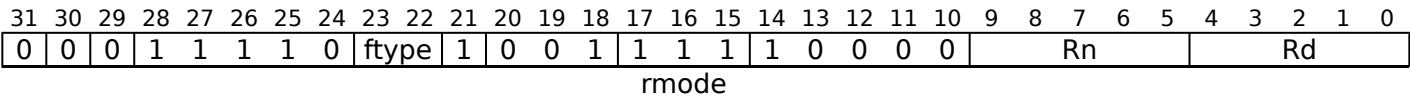
# FRINTI (scalar)

Floating-point Round to Integral, using current rounding mode (scalar). This instruction rounds a floating-point value in the SIMD&FP source register to an integral floating-point value of the same size using the rounding mode that is determined by the [FPCR](#), and writes the result to the SIMD&FP destination register.

A zero input gives a zero result with the same sign, an infinite input gives an infinite result with the same sign, and a NaN is propagated as for normal arithmetic.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (FEAT\_FP16)

FRINTI <Hd>, <Hn>

## Single-precision (ftype == 00)

FRINTI <Sd>, <Sn>

## Double-precision (ftype == 01)

FRINTI <Dd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize;
case ftype of
    when '00' esize = 32;
    when '01' esize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            esize = 16;
        else
            UNDEFINED;

FPRounding rounding;
rounding = FPRoundingMode(FPCR[]);
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
FPCRTYPE fpcr = FPCR[];  
boolean merge = IsMerging(fpcr);  
bits(128) result = if merge then V[d] else Zeros();  
bits(esize) operand = V[n];  
  
Elem[result, 0, esize] = FPRoundInt(operand, fpcr, rounding, FALSE);  
  
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FRINTM (vector)

Floating-point Round to Integral, toward Minus infinity (vector). This instruction rounds a vector of floating-point values in the SIMD&FP source register to integral floating-point values of the same size using the Round towards Minus Infinity rounding mode, and writes the result to the SIMD&FP destination register.

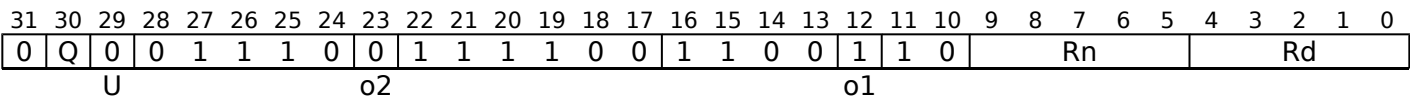
A zero input gives a zero result with the same sign, an infinite input gives an infinite result with the same sign, and a NaN is propagated as for normal arithmetic.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (FEAT\_FP16)



FRINTM <Vd>.<T>, <Vn>.<T>

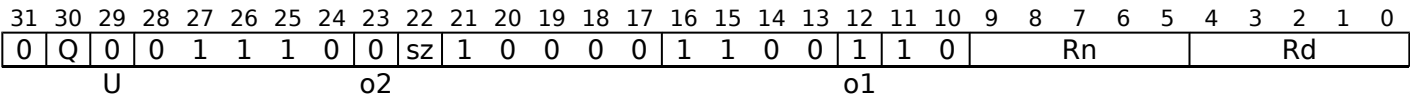
```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean exact = FALSE;
FPRounding rounding;
case U:o1:o2 of
  when '0xx' rounding = FPDecodeRounding(o1:o2);
  when '100' rounding = FPRounding_TIEAWAY;
  when '101' UNDEFINED;
  when '110' rounding = FPRoundingMode(FPCR[]); exact = TRUE;
  when '111' rounding = FPRoundingMode(FPCR[]);
```

## Single-precision and double-precision



**FRINTM** <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean exact = FALSE;
FPRounding rounding;
case U:o1:o2 of
  when '0xx' rounding = FPDecodeRounding(o1:o2);
  when '100' rounding = FPRounding_TIEAWAY;
  when '101' UNDEFINED;
  when '110' rounding = FPRoundingMode(FPCR[]); exact = TRUE;
  when '111' rounding = FPRoundingMode(FPCR[]);
```

### Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

### Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
  element = Elem[operand, e, esize];
  Elem[result, e, esize] = FPRoundInt(element, FPCR[], rounding, exact);
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



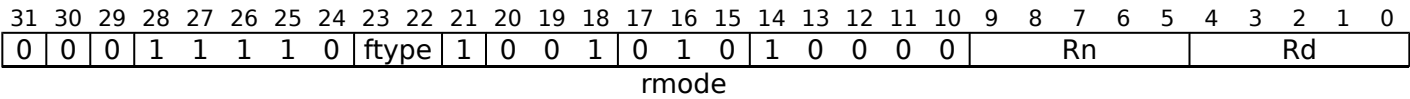
# FRINTM (scalar)

Floating-point Round to Integral, toward Minus infinity (scalar). This instruction rounds a floating-point value in the SIMD&FP source register to an integral floating-point value of the same size using the Round towards Minus Infinity rounding mode, and writes the result to the SIMD&FP destination register.

A zero input gives a zero result with the same sign, an infinite input gives an infinite result with the same sign, and a NaN is propagated as for normal arithmetic.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (FEAT\_FP16)

FRINTM <Hd>, <Hn>

## Single-precision (ftype == 00)

FRINTM <Sd>, <Sn>

## Double-precision (ftype == 01)

FRINTM <Dd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize;
case ftype of
    when '00' esize = 32;
    when '01' esize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            esize = 16;
        else
            UNDEFINED;

FPRounding rounding;
rounding = FPDecodeRounding('10');
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
FPCRTYPE fpcr = FPCR[];  
boolean merge = IsMerging(fpcr);  
bits(128) result = if merge then V[d] else Zeros();  
bits(esize) operand = V[n];  
  
Elem[result, 0, esize] = FPRoundInt(operand, fpcr, rounding, FALSE);  
  
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FRINTN (vector)

Floating-point Round to Integral, to nearest with ties to even (vector). This instruction rounds a vector of floating-point values in the SIMD&FP source register to integral floating-point values of the same size using the Round to Nearest rounding mode, and writes the result to the SIMD&FP destination register.

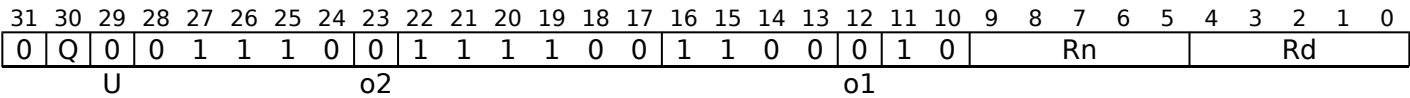
A zero input gives a zero result with the same sign, an infinite input gives an infinite result with the same sign, and a NaN is propagated as for normal arithmetic.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

Half-precision  
(FEAT\_FP16)



FRINTN <Vd>.<T>, <Vn>.<T>

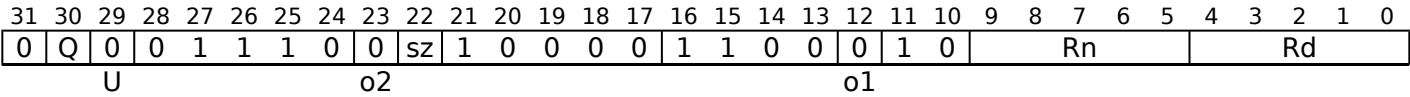
```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean exact = FALSE;
FPRounding rounding;
case U:o1:o2 of
  when '0xx' rounding = FPDecodeRounding(o1:o2);
  when '100' rounding = FPRounding_TIEAWAY;
  when '101' UNDEFINED;
  when '110' rounding = FPRoundingMode(FPCR[]); exact = TRUE;
  when '111' rounding = FPRoundingMode(FPCR[]);
```

Single-precision and double-precision



**FRINTN** <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean exact = FALSE;
FPRounding rounding;
case U:o1:o2 of
  when '0xx' rounding = FPDecodeRounding(o1:o2);
  when '100' rounding = FPRounding_TIEAWAY;
  when '101' UNDEFINED;
  when '110' rounding = FPRoundingMode(FPCR[]); exact = TRUE;
  when '111' rounding = FPRoundingMode(FPCR[]);
```

### Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

### Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
  element = Elem[operand, e, esize];
  Elem[result, e, esize] = FPRoundInt(element, FPCR[], rounding, exact);
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

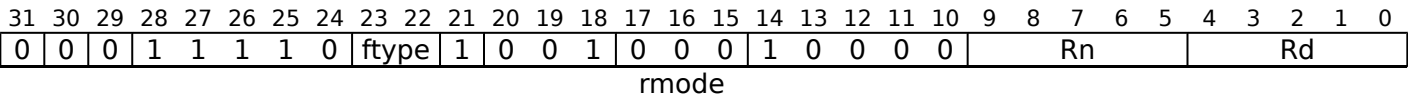
# FRINTN (scalar)

Floating-point Round to Integral, to nearest with ties to even (scalar). This instruction rounds a floating-point value in the SIMD&FP source register to an integral floating-point value of the same size using the Round to Nearest rounding mode, and writes the result to the SIMD&FP destination register.

A zero input gives a zero result with the same sign, an infinite input gives an infinite result with the same sign, and a NaN is propagated as for normal arithmetic.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (FEAT\_FP16)

FRINTN <Hd>, <Hn>

## Single-precision (ftype == 00)

FRINTN <Sd>, <Sn>

## Double-precision (ftype == 01)

FRINTN <Dd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize;
case ftype of
    when '00' esize = 32;
    when '01' esize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            esize = 16;
        else
            UNDEFINED;

FPRounding rounding;
rounding = FPDecodeRounding('00');
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
FPCRTYPE fpcr = FPCR[];  
boolean merge = IsMerging(fpcr);  
bits(128) result = if merge then V[d] else Zeros();  
bits(esize) operand = V[n];  
  
Elem[result, 0, esize] = FPRoundInt(operand, fpcr, rounding, FALSE);  
  
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## FRINTP (vector)

Floating-point Round to Integral, toward Plus infinity (vector). This instruction rounds a vector of floating-point values in the SIMD&FP source register to integral floating-point values of the same size using the Round towards Plus Infinity rounding mode, and writes the result to the SIMD&FP destination register.

A zero input gives a zero result with the same sign, an infinite input gives an infinite result with the same sign, and a NaN is propagated as for normal arithmetic.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

### Half-precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	1	1	1	1	0	0	1	1	0	0	0	1	0	Rn				Rd					
U								o2				o1																			

FRINTP <Vd>.<T>, <Vn>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean exact = FALSE;
FPRounding rounding;
case U:o1:o2 of
    when '0xx' rounding = FPDecodeRounding(o1:o2);
    when '100' rounding = FPRounding_TIEAWAY;
    when '101' UNDEFINED;
    when '110' rounding = FPRoundingMode(FPCR[]); exact = TRUE;
    when '111' rounding = FPRoundingMode(FPCR[]);
```

### Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	sz	1	0	0	0	0	1	1	0	0	0	1	0	Rn				Rd					
U								o2				o1																			

FRINTP <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean exact = FALSE;
FPRounding rounding;
case U:o1:o2 of
  when '0xx' rounding = FPDecodeRounding(o1:o2);
  when '100' rounding = FPRounding_TIEAWAY;
  when '101' UNDEFINED;
  when '110' rounding = FPRoundingMode(FPCR[]); exact = TRUE;
  when '111' rounding = FPRoundingMode(FPCR[]);
```

### Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

### Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
  element = Elem[operand, e, esize];
  Elem[result, e, esize] = FPRoundInt(element, FPCR[], rounding, exact);
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



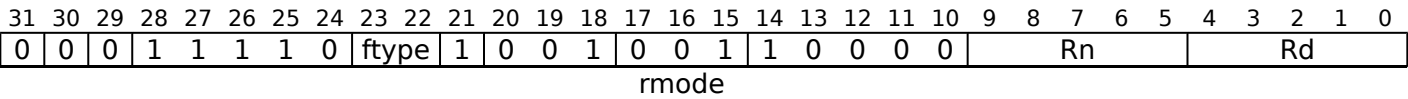
# FRINTP (scalar)

Floating-point Round to Integral, toward Plus infinity (scalar). This instruction rounds a floating-point value in the SIMD&FP source register to an integral floating-point value of the same size using the Round towards Plus Infinity rounding mode, and writes the result to the SIMD&FP destination register.

A zero input gives a zero result with the same sign, an infinite input gives an infinite result with the same sign, and a NaN is propagated as for normal arithmetic.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (FEAT\_FP16)

```
FRINTP <Hd>, <Hn>
```

## Single-precision (ftype == 00)

```
FRINTP <Sd>, <Sn>
```

## Double-precision (ftype == 01)

```
FRINTP <Dd>, <Dn>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize;
case ftype of
    when '00' esize = 32;
    when '01' esize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            esize = 16;
        else
            UNDEFINED;

FPRounding rounding;
rounding = FPDecodeRounding('01');
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
FPCRTYPE fpcr = FPCR[];  
boolean merge = IsMerging(fpcr);  
bits(128) result = if merge then V[d] else Zeros();  
bits(esize) operand = V[n];  
  
Elem[result, 0, esize] = FPRoundInt(operand, fpcr, rounding, FALSE);  
  
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FRINTX (vector)

Floating-point Round to Integral exact, using current rounding mode (vector). This instruction rounds a vector of floating-point values in the SIMD&FP source register to integral floating-point values of the same size using the rounding mode that is determined by the *FPCR*, and writes the result to the SIMD&FP destination register.

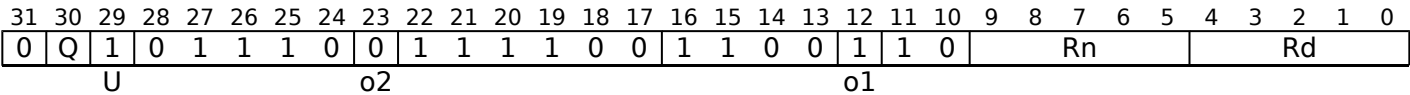
When a result value is not numerically equal to the corresponding input value, an Inexact exception is raised. A zero input gives a zero result with the same sign, an infinite input gives an infinite result with the same sign, and a NaN is propagated as for normal arithmetic.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

Half-precision  
(FEAT\_FP16)



FRINTX <Vd>.<T>, <Vn>.<T>

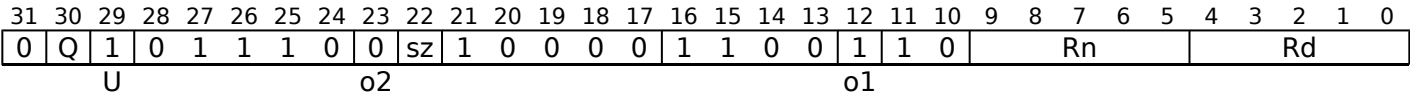
```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean exact = FALSE;
FPRounding rounding;
case U:o1:o2 of
  when '0xx' rounding = FPDecodeRounding(o1:o2);
  when '100' rounding = FPRounding_TIEAWAY;
  when '101' UNDEFINED;
  when '110' rounding = FPRoundingMode(FPCR[]); exact = TRUE;
  when '111' rounding = FPRoundingMode(FPCR[]);
```

Single-precision and double-precision



FRINTX <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean exact = FALSE;
FPRounding rounding;
case U:o1:o2 of
  when '0xx' rounding = FPDecodeRounding(o1:o2);
  when '100' rounding = FPRounding_TIEAWAY;
  when '101' UNDEFINED;
  when '110' rounding = FPRoundingMode(FPCR[]); exact = TRUE;
  when '111' rounding = FPRoundingMode(FPCR[]);
```

### Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

### Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
  element = Elem[operand, e, esize];
  Elem[result, e, esize] = FPRoundInt(element, FPCR[], rounding, exact);
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FRINTX (scalar)

Floating-point Round to Integral exact, using current rounding mode (scalar). This instruction rounds a floating-point value in the SIMD&FP source register to an integral floating-point value of the same size using the rounding mode that is determined by the [FPCR](#), and writes the result to the SIMD&FP destination register.

When the result value is not numerically equal to the input value, an Inexact exception is raised. A zero input gives a zero result with the same sign, an infinite input gives an infinite result with the same sign, and a NaN is propagated as for normal arithmetic.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	0	0	1	1	1	1	0	f	t	y	p	e	1	0	0	1	1	1	0	1	0	0	0	0	Rn				Rd			
rmode																																

## Half-precision (ftype == 11) (FEAT\_FP16)

FRINTX <Hd>, <Hn>

## Single-precision (ftype == 00)

FRINTX <Sd>, <Sn>

## Double-precision (ftype == 01)

FRINTX <Dd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize;
case ftype of
    when '00' esize = 32;
    when '01' esize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            esize = 16;
        else
            UNDEFINED;

FPRounding rounding;
rounding = FPRoundingMode(FPCR[]);
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
FPCRTYPE fpcr = FPCR[];  
boolean merge = IsMerging(fpcr);  
bits(128) result = if merge then V[d] else Zeros();  
bits(esize) operand = V[n];  
  
Elem[result, 0, esize] = FPRoundInt(operand, fpcr, rounding, TRUE);  
  
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## FRINTZ (vector)

Floating-point Round to Integral, toward Zero (vector). This instruction rounds a vector of floating-point values in the SIMD&FP source register to integral floating-point values of the same size using the Round towards Zero rounding mode, and writes the result to the SIMD&FP destination register.

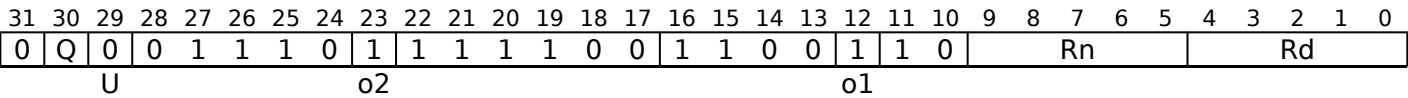
A zero input gives a zero result with the same sign, an infinite input gives an infinite result with the same sign, and a NaN is propagated as for normal arithmetic.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

### Half-precision (FEAT\_FP16)



FRINTZ <Vd>.<T>, <Vn>.<T>

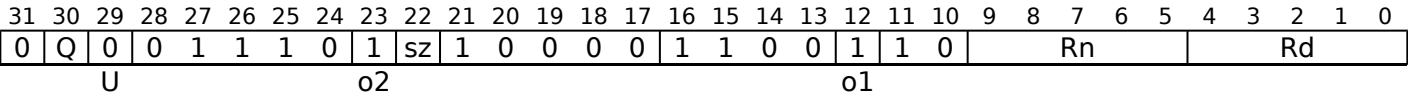
```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean exact = FALSE;
FPRounding rounding;
case U:o1:o2 of
    when '0xx' rounding = FPDecodeRounding(o1:o2);
    when '100' rounding = FPRounding_TIEAWAY;
    when '101' UNDEFINED;
    when '110' rounding = FPRoundingMode(FPCR[]); exact = TRUE;
    when '111' rounding = FPRoundingMode(FPCR[]);
```

### Single-precision and double-precision



FRINTZ <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean exact = FALSE;
FPRounding rounding;
case U:o1:o2 of
  when '0xx' rounding = FPDecodeRounding(o1:o2);
  when '100' rounding = FPRounding_TIEAWAY;
  when '101' UNDEFINED;
  when '110' rounding = FPRoundingMode(FPCR[]); exact = TRUE;
  when '111' rounding = FPRoundingMode(FPCR[]);
```

### Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

### Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
  element = Elem[operand, e, esize];
  Elem[result, e, esize] = FPRoundInt(element, FPCR[], rounding, exact);
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



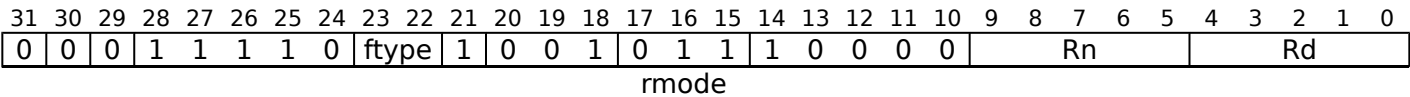
# FRINTZ (scalar)

Floating-point Round to Integral, toward Zero (scalar). This instruction rounds a floating-point value in the SIMD&FP source register to an integral floating-point value of the same size using the Round towards Zero rounding mode, and writes the result to the SIMD&FP destination register.

A zero input gives a zero result with the same sign, an infinite input gives an infinite result with the same sign, and a NaN is propagated as for normal arithmetic.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (FEAT\_FP16)

FRINTZ <Hd>, <Hn>

## Single-precision (ftype == 00)

FRINTZ <Sd>, <Sn>

## Double-precision (ftype == 01)

FRINTZ <Dd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize;
case ftype of
    when '00' esize = 32;
    when '01' esize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            esize = 16;
        else
            UNDEFINED;

FPRounding rounding;
rounding = FPDecodeRounding('11');
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
FPCRTYPE fpcr = FPCR[];  
boolean merge = IsMerging(fpcr);  
bits(128) result = if merge then V[d] else Zeros();  
bits(esize) operand = V[n];  
  
Elem[result, 0, esize] = FPRoundInt(operand, fpcr, rounding, FALSE);  
  
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## FRSQRTE

Floating-point Reciprocal Square Root Estimate. This instruction calculates an approximate square root for each vector element in the source SIMD&FP register, places the result in a vector, and writes the vector to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#) or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#), [Scalar single-precision and double-precision](#), [Vector half precision](#) and [Vector single-precision and double-precision](#)

### Scalar half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	1	1	1	1	1	0	0	1	1	1	0	1	1	0	Rn				Rd					

FRSQRTE <Hd>, <Hn>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;
```

### Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	1	sz	1	0	0	0	0	1	1	1	0	1	1	0	Rn				Rd					

FRSQRTE <V><d>, <V><n>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
```

### Vector half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	1	1	1	1	0	0	1	1	1	0	1	1	0	Rn				Rd					

FRSQRTE <Vd>.<T>, <Vn>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Vector single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	sz	1	0	0	0	0	1	1	1	0	1	1	0	Rn				Rd					

FRSQRTE <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];

bits(esize) element;
FPCRTYPE fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[d] else Zeros();

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPRSqrtEstimate(element, fpcr);

V[d] = result;
```



## FRSQRTS

Floating-point Reciprocal Square Root Step. This instruction multiplies corresponding floating-point values in the vectors of the two source SIMD&FP registers, subtracts each of the products from 3.0, divides these results by 2.0, places the results into a vector, and writes the vector to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#), [Scalar single-precision and double-precision](#), [Vector half precision](#) and [Vector single-precision and double-precision](#)

### Scalar half precision

(FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	1	1	0	Rm				0	0	1	1	1	1	Rn				Rd						

FRSQRTS <Hd>, <Hn>, <Hm>

```
if !HaveFP16Ext() then UNDEFINED;
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = esize;
integer elements = 1;
```

### Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	1	sz	1	Rm				1	1	1	1	1	1	Rn				Rd						

FRSQRTS <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
```

### Vector half precision

(FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	1	0	Rm				0	0	1	1	1	1	Rn				Rd						

FRSQRTS <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Vector single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	sz	1	Rm					1	1	1	1	1	1	Rn					Rd				

FRSQRTS <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];

bits(esize) element1;
bits(esize) element2;
FPCRType fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[n] else Zeros();

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = FPRSqrtStepFused(element1, element2);

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



FSQRT (vector)

Floating-point Square Root (vector). This instruction calculates the square root for each vector element in the source SIMD&FP register, places the result in a vector, and writes the vector to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

Half-precision  
(FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	1	1	1	1	0	0	1	1	1	1	1	1	0	Rn				Rd					

FSQRT <Vd>.<T>, <Vn>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	sz	1	0	0	0	0	1	1	1	1	1	1	0	Rn				Rd					

FSQRT <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPSqrt(element, FPCR[]);

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

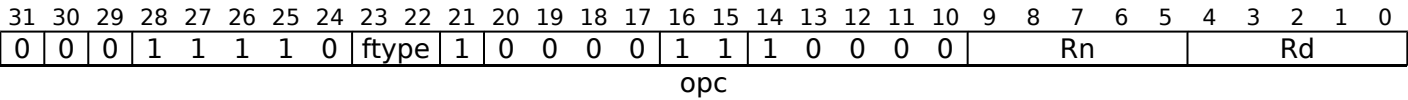
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FSQRT (scalar)

Floating-point Square Root (scalar). This instruction calculates the square root of the value in the SIMD&FP source register and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (FEAT\_FP16)

FSQRT <Hd>, <Hn>

## Single-precision (ftype == 00)

FSQRT <Sd>, <Sn>

## Double-precision (ftype == 01)

FSQRT <Dd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize;
case ftype of
    when '00' esize = 32;
    when '01' esize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            esize = 16;
        else
            UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
FPCRType fpcr = FPCR[];  
boolean merge = IsMerging(fpcr);  
bits(128) result = if merge then V[d] else Zeros();  
  
bits(esize) operand = V[n];  
  
Elem[result, 0, esize] = FPSqrt(operand, fpcr);  
  
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FSUB (vector)

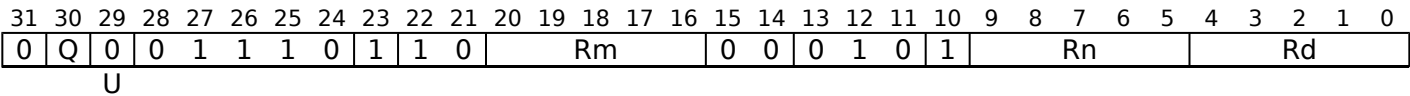
Floating-point Subtract (vector). This instruction subtracts the elements in the vector in the second source SIMD&FP register, from the corresponding elements in the vector in the first source SIMD&FP register, places each result into elements of a vector, and writes the vector to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

Half-precision  
(FEAT\_FP16)

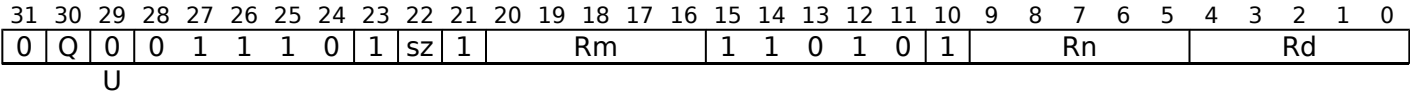


FSUB <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean abs = (U == '1');
```

Single-precision and double-precision



FSUB <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean abs = (U == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];

bits(esize) element1;
bits(esize) element2;
bits(esize) diff;
FPCRTType fpcr = FPCR[];
bits(datasize) result;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    diff = FPSub(element1, element2, fpcr);
    Elem[result, e, esize] = if abs then FPAbs(diff) else diff;

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

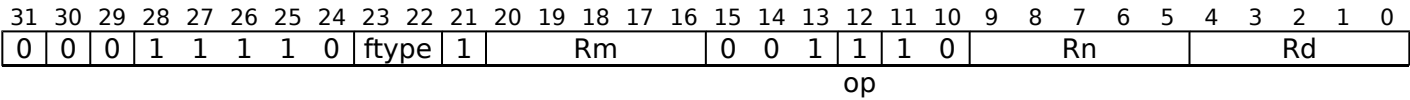
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FSUB (scalar)

Floating-point Subtract (scalar). This instruction subtracts the floating-point value of the second source SIMD&FP register from the floating-point value of the first source SIMD&FP register, and writes the result to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (FEAT\_FP16)

FSUB <Hd>, <Hn>, <Hm>

## Single-precision (ftype == 00)

FSUB <Sd>, <Sn>, <Sm>

## Double-precision (ftype == 01)

FSUB <Dd>, <Dn>, <Dm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer esize;
case ftype of
    when '00' esize = 32;
    when '01' esize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            esize = 16;
        else
            UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Dm> Is the 64-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Sm> Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
bits(esize) operand1 = V[n];  
bits(esize) operand2 = V[m];  
  
FPCRTYPE fpcr = FPCR[];  
boolean merge = IsMerging(fpcr);  
bits(128) result = if merge then V[n] else Zeros();  
  
Elem[result, 0, esize] = FPSub(operand1, operand2, fpcr);  
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



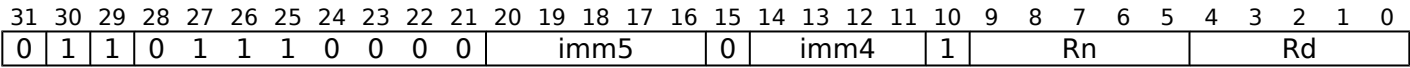
INS (element)

Insert vector element from another vector element. This instruction copies the vector element of the source SIMD&FP register to the specified vector element of the destination SIMD&FP register.

This instruction can insert data into individual elements within a SIMD&FP register without clearing the remaining bits to zero.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This instruction is used by the alias MOV(element).



INS <Vd>.<Ts>[<index1>], <Vn>.<Ts>[<index2>]

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer size = LowestSetBit(imm5);
if size > 3 then UNDEFINED;

integer dst_index = UInt(imm5<4:size+1>);
integer src_index = UInt(imm4<3:size>);
integer idxsize = if imm4<3> == '1' then 128 else 64;
// imm4<size-1:0> is IGNORED

integer esize = 8 << size;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ts> Is an element size specifier, encoded in "imm5":

imm5	<Ts>
x0000	RESERVED
xxx1	B
xxx10	H
xx100	S
x1000	D

<index1> Is the destination element index encoded in "imm5":

imm5	<index1>
x0000	RESERVED
xxx1	imm5<4:1>
xxx10	imm5<4:2>
xx100	imm5<4:3>
x1000	imm5<4>

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<index2> Is the source element index encoded in "imm5:imm4":

imm5	<index2>
x0000	RESERVED
xxx1	imm4<3:0>
xxx10	imm4<3:1>
xx100	imm4<3:2>
x1000	imm4<3>

Unspecified bits in "imm4" are ignored but should be set to zero by an assembler.

## Operation

```
CheckFPAdvSIMDEnabled64();  
bits(idxsize) operand = V[n];  
bits(128) result;  
  
result = V[d];  
Elem[result, dst_index, esize] = Elem[operand, src_index, esize];  
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

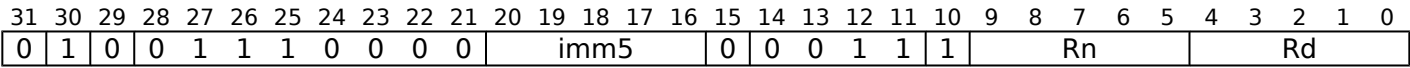
# INS (general)

Insert vector element from general-purpose register. This instruction copies the contents of the source general-purpose register to the specified vector element in the destination SIMD&FP register.

This instruction can insert data into individual elements within a SIMD&FP register without clearing the remaining bits to zero.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This instruction is used by the alias [MOV \(from general\)](#).



INS <Vd>.<Ts>[<index>], <R><n>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer size = LowestSetBit(imm5);

if size > 3 then UNDEFINED;
integer index = UInt(imm5<4:size+1>);

integer esize = 8 << size;
```

## Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ts> Is an element size specifier, encoded in "imm5":

imm5	<Ts>
x0000	RESERVED
xxx1	B
xx10	H
xx100	S
x1000	D

<index> Is the element index encoded in "imm5":

imm5	<index>
x0000	RESERVED
xxx1	imm5<4:1>
xx10	imm5<4:2>
xx100	imm5<4:3>
x1000	imm5<4>

<R> Is the width specifier for the general-purpose source register, encoded in "imm5":

imm5	<R>
x0000	RESERVED
xxx1	W
xx10	W
xx100	W
x1000	X

<n> Is the number [0-30] of the general-purpose source register or ZR (31), encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
bits(esize) element = X[n];  
bits(128) result;  
  
result = V[d];  
Elem[result, index, esize] = element;  
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LD1 (multiple structures)

Load multiple single-element structures to one, two, three, or four registers. This instruction loads multiple single-element structures from memory and writes the result to one, two, three, or four SIMD&FP registers. Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

## No offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	0	0	1	0	0	0	0	0	0	x	x	1	x	size		Rn				Rt					
L										opcode																					

## One register (opcode == 0111)

LD1 { <Vt>.<T> }, [<Xn|SP>]

## Two registers (opcode == 1010)

LD1 { <Vt>.<T>, <Vt2>.<T> }, [<Xn|SP>]

## Three registers (opcode == 0110)

LD1 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T> }, [<Xn|SP>]

## Four registers (opcode == 0010)

LD1 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T>, <Vt4>.<T> }, [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

## Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	0	1	1	0	Rm					x	x	1	x	size			Rn				Rt				
L										opcode																					

**One register, immediate offset (Rm == 11111 && opcode == 0111)**

```
LD1 { <Vt>.<T> }, [<Xn|SP>], <imm>
```

**One register, register offset (Rm != 11111 && opcode == 0111)**

```
LD1 { <Vt>.<T> }, [<Xn|SP>], <Xm>
```

**Two registers, immediate offset (Rm == 11111 && opcode == 1010)**

```
LD1 { <Vt>.<T>, <Vt2>.<T> }, [<Xn|SP>], <imm>
```

**Two registers, register offset (Rm != 11111 && opcode == 1010)**

```
LD1 { <Vt>.<T>, <Vt2>.<T> }, [<Xn|SP>], <Xm>
```

**Three registers, immediate offset (Rm == 11111 && opcode == 0110)**

```
LD1 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T> }, [<Xn|SP>], <imm>
```

**Three registers, register offset (Rm != 11111 && opcode == 0110)**

```
LD1 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T> }, [<Xn|SP>], <Xm>
```

**Four registers, immediate offset (Rm == 11111 && opcode == 0010)**

```
LD1 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T>, <Vt4>.<T> }, [<Xn|SP>], <imm>
```

**Four registers, register offset (Rm != 11111 && opcode == 0010)**

```
LD1 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T>, <Vt4>.<T> }, [<Xn|SP>], <Xm>
```

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

**Assembler Symbols**

<Vt> Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	1D
11	1	2D

<Vt2> Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.

<Vt3> Is the name of the third SIMD&FP register to be transferred, encoded as "Rt" plus 2 modulo 32.

<Vt4> Is the name of the fourth SIMD&FP register to be transferred, encoded as "Rt" plus 3 modulo 32.

<Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

<imm> For the one register, immediate offset variant: is the post-index immediate offset, encoded in "Q":

Q	<imm>
0	#8
1	#16

For the two registers, immediate offset variant: is the post-index immediate offset, encoded in "Q":

Q	<imm>
0	#16
1	#32

For the three registers, immediate offset variant: is the post-index immediate offset, encoded in "Q":

Q	<imm>
0	#24
1	#48

For the four registers, immediate offset variant: is the post-index immediate offset, encoded in "Q":

Q	<imm>
0	#32
1	#64

<Xm> Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

## Shared Decode

```
MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << UInt(size);
integer elements = datasize DIV esize;

integer rpt;    // number of iterations
integer selem;  // structure elements

case opcode of
  when '0000' rpt = 1; selem = 4;    // LD/ST4 (4 registers)
  when '0010' rpt = 4; selem = 1;    // LD/ST1 (4 registers)
  when '0100' rpt = 1; selem = 3;    // LD/ST3 (3 registers)
  when '0110' rpt = 3; selem = 1;    // LD/ST1 (3 registers)
  when '0111' rpt = 1; selem = 1;    // LD/ST1 (1 register)
  when '1000' rpt = 1; selem = 2;    // LD/ST2 (2 registers)
  when '1010' rpt = 2; selem = 1;    // LD/ST1 (2 registers)
  otherwise UNDEFINED;

// .1D format only permitted with LD1 & ST1
if size:Q == '110' && selem != 1 then UNDEFINED;
```

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(datasize) rval;
integer tt;
constant integer ebytes = esize DIV 8;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
for r = 0 to rpt-1
    for e = 0 to elements-1
        tt = (t + r) MOD 32;
        for s = 0 to selem-1
            rval = V[tt];
            if memop == MemOp_LOAD then
                Elem[rval, e, esize] = Mem[address+offs, ebytes, AccType_VEC];
                V[tt] = rval;
            else // memop == MemOp_STORE
                Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, e, esize];
                offs = offs + ebytes;
                tt = (tt + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# LD1 (single structure)

Load one single-element structure to one lane of one register. This instruction loads a single-element structure from memory and writes the result to the specified lane of the SIMD&FP register without affecting the other bits of the register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

## No offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	0	1	0	0	0	0	0	0	x	x	0	S	size	Rn				Rt						
L										R	opcode																				

## 8-bit (opcode == 000)

LD1 { <Vt>.B }[<index>], [<Xn|SP>]

## 16-bit (opcode == 010 && size == x0)

LD1 { <Vt>.H }[<index>], [<Xn|SP>]

## 32-bit (opcode == 100 && size == 00)

LD1 { <Vt>.S }[<index>], [<Xn|SP>]

## 64-bit (opcode == 100 && S == 0 && size == 01)

LD1 { <Vt>.D }[<index>], [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

## Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	1	1	0	Rm				x	x	0	S	size	Rn				Rt							
L										R	opcode																				

**8-bit, immediate offset (Rm == 11111 && opcode == 000)**

```
LD1 { <Vt>.B }[<index>], [<Xn|SP>], #1
```

**8-bit, register offset (Rm != 11111 && opcode == 000)**

```
LD1 { <Vt>.B }[<index>], [<Xn|SP>], <Xm>
```

**16-bit, immediate offset (Rm == 11111 && opcode == 010 && size == x0)**

```
LD1 { <Vt>.H }[<index>], [<Xn|SP>], #2
```

**16-bit, register offset (Rm != 11111 && opcode == 010 && size == x0)**

```
LD1 { <Vt>.H }[<index>], [<Xn|SP>], <Xm>
```

**32-bit, immediate offset (Rm == 11111 && opcode == 100 && size == 00)**

```
LD1 { <Vt>.S }[<index>], [<Xn|SP>], #4
```

**32-bit, register offset (Rm != 11111 && opcode == 100 && size == 00)**

```
LD1 { <Vt>.S }[<index>], [<Xn|SP>], <Xm>
```

**64-bit, immediate offset (Rm == 11111 && opcode == 100 && S == 0 && size == 01)**

```
LD1 { <Vt>.D }[<index>], [<Xn|SP>], #8
```

**64-bit, register offset (Rm != 11111 && opcode == 100 && S == 0 && size == 01)**

```
LD1 { <Vt>.D }[<index>], [<Xn|SP>], <Xm>
```

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

**Assembler Symbols**

<Vt>	Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
<index>	For the 8-bit variant: is the element index, encoded in "Q:S:size". For the 16-bit variant: is the element index, encoded in "Q:S:size<1>". For the 32-bit variant: is the element index, encoded in "Q:S". For the 64-bit variant: is the element index, encoded in "Q".
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

## Shared Decode

```
integer init_scale = UInt(opcode<2:1>);
integer scale = init_scale;
integer selem = UInt(opcode<0>:R) + 1;
boolean replicate = FALSE;
integer index;

case scale of
  when 3
    // load and replicate
    if L == '0' || S == '1' then UNDEFINED;
    scale = UInt(size);
    replicate = TRUE;
  when 0
    index = UInt(Q:S:size);    // B[0-15]
  when 1
    if size<0> == '1' then UNDEFINED;
    index = UInt(Q:S:size<1>); // H[0-7]
  when 2
    if size<1> == '1' then UNDEFINED;
    if size<0> == '0' then
      index = UInt(Q:S);    // S[0-3]
    else
      if S == '1' then UNDEFINED;
      index = UInt(Q);    // D[0-1]
      scale = 3;
MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << scale;
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(128) rval;
bits(esize) element;
constant integer ebytes = esize DIV 8;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
if replicate then
    // load and replicate to all elements
    for s = 0 to selem-1
        element = Mem[address+offs, ebytes, AccType_VEC];
        // replicate to fill 128- or 64-bit register
        V[t] = Replicate(element, datasize DIV esize);
        offs = offs + ebytes;
        t = (t + 1) MOD 32;
else
    // load/store one element per register
    for s = 0 to selem-1
        rval = V[t];
        if memop == MemOp_LOAD then
            // insert into one lane of 128-bit register
            Elem[rval, index, esize] = Mem[address+offs, ebytes, AccType_VEC];
            V[t] = rval;
        else // memop == MemOp_STORE
            // extract from one lane of 128-bit register
            Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, index, esize];
            offs = offs + ebytes;
            t = (t + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

LD1R

Load one single-element structure and Replicate to all lanes (of one register). This instruction loads a single-element structure from memory and replicates the structure to all the lanes of the SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

No offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	size	Rn				Rt						
L										R	opcode										S										

LD1R { <Vt>.<T> }, [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	1	1	0	Rm					1	1	0	0	size	Rn				Rt						
L										R	opcode					S															

Immediate offset (Rm == 11111)

LD1R { <Vt>.<T> }, [<Xn|SP>], <imm>

Register offset (Rm != 11111)

LD1R { <Vt>.<T> }, [<Xn|SP>], <Xm>

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

Assembler Symbols

- <Vt> Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	1D
11	1	2D

- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

<imm> Is the post-index immediate offset, encoded in "size":

size	<imm>
00	#1
01	#2
10	#4
11	#8

<Xm> Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

## Shared Decode

```
integer init_scale = UInt(opcode<2:1>);
integer scale = init_scale;
integer selem = UInt(opcode<0>:R) + 1;
boolean replicate = FALSE;
integer index;

case scale of
  when 3
    // load and replicate
    if L == '0' || S == '1' then UNDEFINED;
    scale = UInt(size);
    replicate = TRUE;
  when 0
    index = UInt(Q:S:size);    // B[0-15]
  when 1
    if size<0> == '1' then UNDEFINED;
    index = UInt(Q:S:size<1>); // H[0-7]
  when 2
    if size<1> == '1' then UNDEFINED;
    if size<0> == '0' then
      index = UInt(Q:S);    // S[0-3]
    else
      if S == '1' then UNDEFINED;
      index = UInt(Q);    // D[0-1]
      scale = 3;
MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << scale;
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(128) rval;
bits(esize) element;
constant integer ebytes = esize DIV 8;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
if replicate then
    // load and replicate to all elements
    for s = 0 to selem-1
        element = Mem[address+offs, ebytes, AccType_VEC];
        // replicate to fill 128- or 64-bit register
        V[t] = Replicate(element, datasize DIV esize);
        offs = offs + ebytes;
        t = (t + 1) MOD 32;
else
    // load/store one element per register
    for s = 0 to selem-1
        rval = V[t];
        if memop == MemOp_LOAD then
            // insert into one lane of 128-bit register
            Elem[rval, index, esize] = Mem[address+offs, ebytes, AccType_VEC];
            V[t] = rval;
        else // memop == MemOp_STORE
            // extract from one lane of 128-bit register
            Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, index, esize];
            offs = offs + ebytes;
            t = (t + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

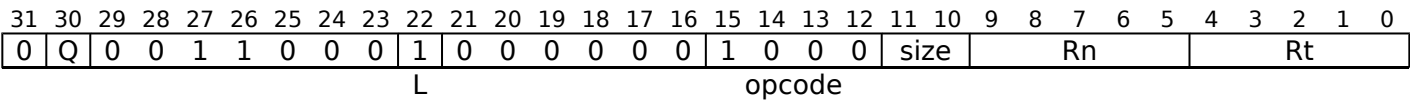
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

LD2 (multiple structures)

Load multiple 2-element structures to two registers. This instruction loads multiple 2-element structures from memory and writes the result to the two SIMD&FP registers, with de-interleaving.  
For an example of de-interleaving, see LD3 (multiple structures).  
Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: No offset and Post-index

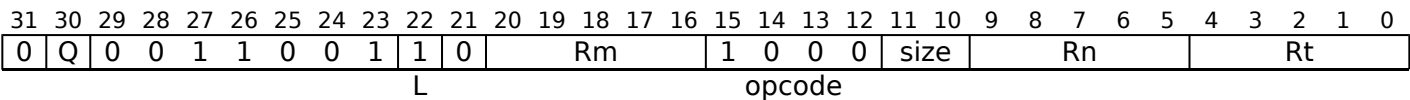
No offset



```
LD2 { <Vt>.<T>, <Vt2>.<T> }, [<Xn|SP>]
```

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

Post-index



Immediate offset (Rm == 11111)

```
LD2 { <Vt>.<T>, <Vt2>.<T> }, [<Xn|SP>], <imm>
```

Register offset (Rm != 11111)

```
LD2 { <Vt>.<T>, <Vt2>.<T> }, [<Xn|SP>], <Xm>
```

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

Assembler Symbols

- <Vt> Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vt2> Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.



- <Xn|SP>      Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm>        Is the post-index immediate offset, encoded in "Q":

Q	<imm>
0	#16
1	#32
- <Xm>        Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

Shared Decode

```
MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << UInt(size);
integer elements = datasize DIV esize;

integer rpt;      // number of iterations
integer selem;    // structure elements

case opcode of
  when '0000' rpt = 1; selem = 4;      // LD/ST4 (4 registers)
  when '0010' rpt = 4; selem = 1;      // LD/ST1 (4 registers)
  when '0100' rpt = 1; selem = 3;      // LD/ST3 (3 registers)
  when '0110' rpt = 3; selem = 1;      // LD/ST1 (3 registers)
  when '0111' rpt = 1; selem = 1;      // LD/ST1 (1 register)
  when '1000' rpt = 1; selem = 2;      // LD/ST2 (2 registers)
  when '1010' rpt = 2; selem = 1;      // LD/ST1 (2 registers)
  otherwise UNDEFINED;

// .LD format only permitted with LD1 & ST1
if size:Q == '110' && selem != 1 then UNDEFINED;
```

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(datasize) rval;
integer tt;
constant integer ebytes = esize DIV 8;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
for r = 0 to rpt-1
    for e = 0 to elements-1
        tt = (t + r) MOD 32;
        for s = 0 to selem-1
            rval = V[tt];
            if memop == MemOp_LOAD then
                Elem[rval, e, esize] = Mem[address+offs, ebytes, AccType_VEC];
                V[tt] = rval;
            else // memop == MemOp_STORE
                Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, e, esize];
                offs = offs + ebytes;
                tt = (tt + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LD2 (single structure)

Load single 2-element structure to one lane of two registers. This instruction loads a 2-element structure from memory and writes the result to the corresponding elements of the two SIMD&FP registers without affecting the other bits of the registers.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

### No offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	0	1	1	0	0	0	0	0	x	x	0	S	size	Rn				Rt						
L										R	opcode																				

### 8-bit (opcode == 000)

LD2 { <Vt>.B, <Vt2>.B }[<index>], [<Xn|SP>]

### 16-bit (opcode == 010 && size == x0)

LD2 { <Vt>.H, <Vt2>.H }[<index>], [<Xn|SP>]

### 32-bit (opcode == 100 && size == 00)

LD2 { <Vt>.S, <Vt2>.S }[<index>], [<Xn|SP>]

### 64-bit (opcode == 100 && S == 0 && size == 01)

LD2 { <Vt>.D, <Vt2>.D }[<index>], [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

### Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	1	1	1	Rm				x	x	0	S	size	Rn				Rt							
L										R	opcode																				

**8-bit, immediate offset (Rm == 11111 && opcode == 000)**

```
LD2 { <Vt>.B, <Vt2>.B }[<index>], [<Xn|SP>], #2
```

**8-bit, register offset (Rm != 11111 && opcode == 000)**

```
LD2 { <Vt>.B, <Vt2>.B }[<index>], [<Xn|SP>], <Xm>
```

**16-bit, immediate offset (Rm == 11111 && opcode == 010 && size == x0)**

```
LD2 { <Vt>.H, <Vt2>.H }[<index>], [<Xn|SP>], #4
```

**16-bit, register offset (Rm != 11111 && opcode == 010 && size == x0)**

```
LD2 { <Vt>.H, <Vt2>.H }[<index>], [<Xn|SP>], <Xm>
```

**32-bit, immediate offset (Rm == 11111 && opcode == 100 && size == 00)**

```
LD2 { <Vt>.S, <Vt2>.S }[<index>], [<Xn|SP>], #8
```

**32-bit, register offset (Rm != 11111 && opcode == 100 && size == 00)**

```
LD2 { <Vt>.S, <Vt2>.S }[<index>], [<Xn|SP>], <Xm>
```

**64-bit, immediate offset (Rm == 11111 && opcode == 100 && S == 0 && size == 01)**

```
LD2 { <Vt>.D, <Vt2>.D }[<index>], [<Xn|SP>], #16
```

**64-bit, register offset (Rm != 11111 && opcode == 100 && S == 0 && size == 01)**

```
LD2 { <Vt>.D, <Vt2>.D }[<index>], [<Xn|SP>], <Xm>
```

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

**Assembler Symbols**

<Vt>	Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
<Vt2>	Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.
<index>	For the 8-bit variant: is the element index, encoded in "Q:S:size". For the 16-bit variant: is the element index, encoded in "Q:S:size<1>". For the 32-bit variant: is the element index, encoded in "Q:S". For the 64-bit variant: is the element index, encoded in "Q".
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

## Shared Decode

```
integer init_scale = UInt(opcode<2:1>);
integer scale = init_scale;
integer selem = UInt(opcode<0>:R) + 1;
boolean replicate = FALSE;
integer index;

case scale of
  when 3
    // load and replicate
    if L == '0' || S == '1' then UNDEFINED;
    scale = UInt(size);
    replicate = TRUE;
  when 0
    index = UInt(Q:S:size);    // B[0-15]
  when 1
    if size<0> == '1' then UNDEFINED;
    index = UInt(Q:S:size<1>); // H[0-7]
  when 2
    if size<1> == '1' then UNDEFINED;
    if size<0> == '0' then
      index = UInt(Q:S);    // S[0-3]
    else
      if S == '1' then UNDEFINED;
      index = UInt(Q);    // D[0-1]
      scale = 3;
MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << scale;
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(128) rval;
bits(esize) element;
constant integer ebytes = esize DIV 8;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
if replicate then
    // load and replicate to all elements
    for s = 0 to selem-1
        element = Mem[address+offs, ebytes, AccType_VEC];
        // replicate to fill 128- or 64-bit register
        V[t] = Replicate(element, datasize DIV esize);
        offs = offs + ebytes;
        t = (t + 1) MOD 32;
else
    // load/store one element per register
    for s = 0 to selem-1
        rval = V[t];
        if memop == MemOp_LOAD then
            // insert into one lane of 128-bit register
            Elem[rval, index, esize] = Mem[address+offs, ebytes, AccType_VEC];
            V[t] = rval;
        else // memop == MemOp_STORE
            // extract from one lane of 128-bit register
            Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, index, esize];
            offs = offs + ebytes;
            t = (t + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

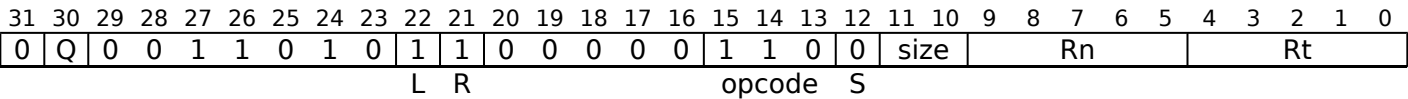
LD2R

Load single 2-element structure and Replicate to all lanes of two registers. This instruction loads a 2-element structure from memory and replicates the structure to all the lanes of the two SIMD&FP registers.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

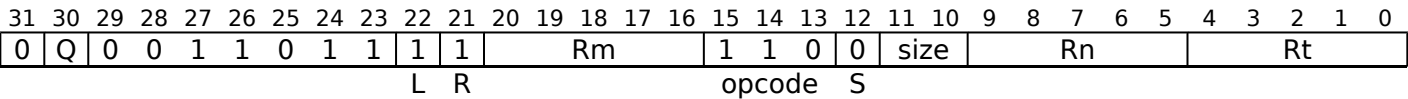
No offset



LD2R { <Vt>.<T>, <Vt2>.<T> }, [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

Post-index



Immediate offset (Rm == 11111)

LD2R { <Vt>.<T>, <Vt2>.<T> }, [<Xn|SP>], <imm>

Register offset (Rm != 11111)

LD2R { <Vt>.<T>, <Vt2>.<T> }, [<Xn|SP>], <Xm>

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

Assembler Symbols

- <Vt> Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	1D
11	1	2D

- <Vt2> Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.

- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the post-index immediate offset, encoded in "size":
- | size | <imm> |
|------|-------|
| 00   | #2    |
| 01   | #4    |
| 10   | #8    |
| 11   | #16   |
- <Xm> Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

## Shared Decode

```

integer init_scale = UInt(opcode<2:1>);
integer scale = init_scale;
integer selem = UInt(opcode<0>:R) + 1;
boolean replicate = FALSE;
integer index;

case scale of
  when 3
    // load and replicate
    if L == '0' || S == '1' then UNDEFINED;
    scale = UInt(size);
    replicate = TRUE;
  when 0
    index = UInt(Q:S:size);    // B[0-15]
  when 1
    if size<0> == '1' then UNDEFINED;
    index = UInt(Q:S:size<1>); // H[0-7]
  when 2
    if size<1> == '1' then UNDEFINED;
    if size<0> == '0' then
      index = UInt(Q:S);    // S[0-3]
    else
      if S == '1' then UNDEFINED;
      index = UInt(Q);    // D[0-1]
      scale = 3;
MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << scale;

```



## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(128) rval;
bits(esize) element;
constant integer ebytes = esize DIV 8;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
if replicate then
    // load and replicate to all elements
    for s = 0 to selem-1
        element = Mem[address+offs, ebytes, AccType_VEC];
        // replicate to fill 128- or 64-bit register
        V[t] = Replicate(element, datasize DIV esize);
        offs = offs + ebytes;
        t = (t + 1) MOD 32;
else
    // load/store one element per register
    for s = 0 to selem-1
        rval = V[t];
        if memop == MemOp_LOAD then
            // insert into one lane of 128-bit register
            Elem[rval, index, esize] = Mem[address+offs, ebytes, AccType_VEC];
            V[t] = rval;
        else // memop == MemOp_STORE
            // extract from one lane of 128-bit register
            Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, index, esize];
            offs = offs + ebytes;
            t = (t + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

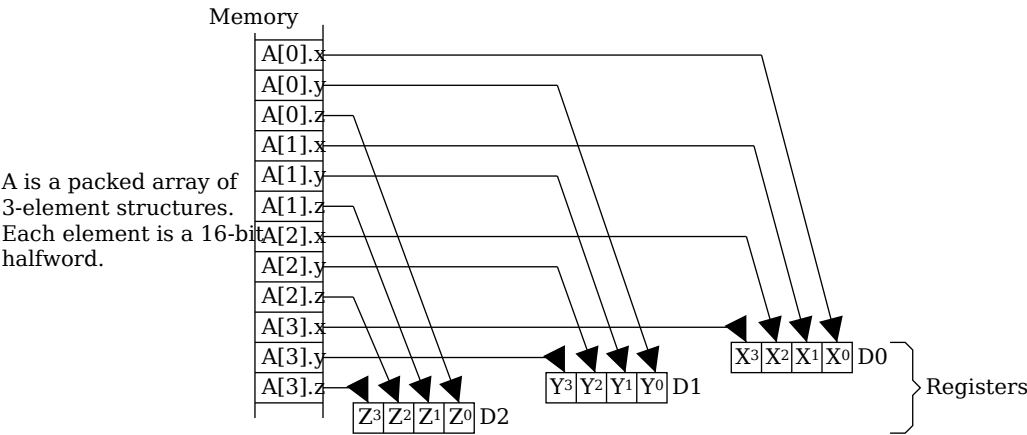
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

LD3 (multiple structures)

Load multiple 3-element structures to three registers. This instruction loads multiple 3-element structures from memory and writes the result to the three SIMD&FP registers, with de-interleaving. The following figure shows an example of the operation of de-interleaving of a LD3.16 (multiple 3-element structures) instruction:.



Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: No offset and Post-index

No offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	size	Rn				Rt						
L										opcode																					

LD3 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T> }, [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	0	1	1	0	Rm				0	1	0	0	size	Rn				Rt							
L										opcode																					

Immediate offset (Rm == 11111)

LD3 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T> }, [<Xn|SP>], <imm>

Register offset (Rm != 11111)

LD3 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T> }, [<Xn|SP>], <Xm>

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

Assembler Symbols

- <Vt>

Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
- <T>

Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D
- <Vt2>

Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.
- <Vt3>

Is the name of the third SIMD&FP register to be transferred, encoded as "Rt" plus 2 modulo 32.
- <Xn|SP>

Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm>

Is the post-index immediate offset, encoded in "Q":

Q	<imm>
0	#24
1	#48
- <Xm>

Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

Shared Decode

```
MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << UInt(size);
integer elements = datasize DIV esize;

integer rpt;    // number of iterations
integer selem;  // structure elements

case opcode of
  when '0000' rpt = 1; selem = 4;    // LD/ST4 (4 registers)
  when '0010' rpt = 4; selem = 1;    // LD/ST1 (4 registers)
  when '0100' rpt = 1; selem = 3;    // LD/ST3 (3 registers)
  when '0110' rpt = 3; selem = 1;    // LD/ST1 (3 registers)
  when '0111' rpt = 1; selem = 1;    // LD/ST1 (1 register)
  when '1000' rpt = 1; selem = 2;    // LD/ST2 (2 registers)
  when '1010' rpt = 2; selem = 1;    // LD/ST1 (2 registers)
  otherwise UNDEFINED;

// .1D format only permitted with LD1 & ST1
if size:Q == '110' && selem != 1 then UNDEFINED;
```

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(datasize) rval;
integer tt;
constant integer ebytes = esize DIV 8;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
for r = 0 to rpt-1
    for e = 0 to elements-1
        tt = (t + r) MOD 32;
        for s = 0 to selem-1
            rval = V[tt];
            if memop == MemOp_LOAD then
                Elem[rval, e, esize] = Mem[address+offs, ebytes, AccType_VEC];
                V[tt] = rval;
            else // memop == MemOp_STORE
                Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, e, esize];
                offs = offs + ebytes;
                tt = (tt + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LD3 (single structure)

Load single 3-element structure to one lane of three registers. This instruction loads a 3-element structure from memory and writes the result to the corresponding elements of the three SIMD&FP registers without affecting the other bits of the registers.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

### No offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	0	1	0	0	0	0	0	0	x	x	1	S	size	Rn			Rt							
L										R	opcode																				

### 8-bit (opcode == 001)

LD3 { <Vt>.B, <Vt2>.B, <Vt3>.B }[<index>], [<Xn|SP>]

### 16-bit (opcode == 011 && size == x0)

LD3 { <Vt>.H, <Vt2>.H, <Vt3>.H }[<index>], [<Xn|SP>]

### 32-bit (opcode == 101 && size == 00)

LD3 { <Vt>.S, <Vt2>.S, <Vt3>.S }[<index>], [<Xn|SP>]

### 64-bit (opcode == 101 && S == 0 && size == 01)

LD3 { <Vt>.D, <Vt2>.D, <Vt3>.D }[<index>], [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

### Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	1	1	0	Rm					x	x	1	S	size	Rn			Rt							
L										R	opcode																				

**8-bit, immediate offset (Rm == 11111 && opcode == 001)**

```
LD3 { <Vt>.B, <Vt2>.B, <Vt3>.B }[<index>], [<Xn|SP>], #3
```

**8-bit, register offset (Rm != 11111 && opcode == 001)**

```
LD3 { <Vt>.B, <Vt2>.B, <Vt3>.B }[<index>], [<Xn|SP>], <Xm>
```

**16-bit, immediate offset (Rm == 11111 && opcode == 011 && size == x0)**

```
LD3 { <Vt>.H, <Vt2>.H, <Vt3>.H }[<index>], [<Xn|SP>], #6
```

**16-bit, register offset (Rm != 11111 && opcode == 011 && size == x0)**

```
LD3 { <Vt>.H, <Vt2>.H, <Vt3>.H }[<index>], [<Xn|SP>], <Xm>
```

**32-bit, immediate offset (Rm == 11111 && opcode == 101 && size == 00)**

```
LD3 { <Vt>.S, <Vt2>.S, <Vt3>.S }[<index>], [<Xn|SP>], #12
```

**32-bit, register offset (Rm != 11111 && opcode == 101 && size == 00)**

```
LD3 { <Vt>.S, <Vt2>.S, <Vt3>.S }[<index>], [<Xn|SP>], <Xm>
```

**64-bit, immediate offset (Rm == 11111 && opcode == 101 && S == 0 && size == 01)**

```
LD3 { <Vt>.D, <Vt2>.D, <Vt3>.D }[<index>], [<Xn|SP>], #24
```

**64-bit, register offset (Rm != 11111 && opcode == 101 && S == 0 && size == 01)**

```
LD3 { <Vt>.D, <Vt2>.D, <Vt3>.D }[<index>], [<Xn|SP>], <Xm>
```

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

**Assembler Symbols**

<Vt>	Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
<Vt2>	Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.
<Vt3>	Is the name of the third SIMD&FP register to be transferred, encoded as "Rt" plus 2 modulo 32.
<index>	For the 8-bit variant: is the element index, encoded in "Q:S:size". For the 16-bit variant: is the element index, encoded in "Q:S:size<1>". For the 32-bit variant: is the element index, encoded in "Q:S". For the 64-bit variant: is the element index, encoded in "Q".
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

## Shared Decode

```
integer init_scale = UInt(opcode<2:1>);
integer scale = init_scale;
integer selem = UInt(opcode<0>:R) + 1;
boolean replicate = FALSE;
integer index;

case scale of
  when 3
    // load and replicate
    if L == '0' || S == '1' then UNDEFINED;
    scale = UInt(size);
    replicate = TRUE;
  when 0
    index = UInt(Q:S:size);    // B[0-15]
  when 1
    if size<0> == '1' then UNDEFINED;
    index = UInt(Q:S:size<1>); // H[0-7]
  when 2
    if size<1> == '1' then UNDEFINED;
    if size<0> == '0' then
      index = UInt(Q:S);    // S[0-3]
    else
      if S == '1' then UNDEFINED;
      index = UInt(Q);    // D[0-1]
      scale = 3;
MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << scale;
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(128) rval;
bits(esize) element;
constant integer ebytes = esize DIV 8;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
if replicate then
    // load and replicate to all elements
    for s = 0 to selem-1
        element = Mem[address+offs, ebytes, AccType_VEC];
        // replicate to fill 128- or 64-bit register
        V[t] = Replicate(element, datasize DIV esize);
        offs = offs + ebytes;
        t = (t + 1) MOD 32;
else
    // load/store one element per register
    for s = 0 to selem-1
        rval = V[t];
        if memop == MemOp_LOAD then
            // insert into one lane of 128-bit register
            Elem[rval, index, esize] = Mem[address+offs, ebytes, AccType_VEC];
            V[t] = rval;
        else // memop == MemOp_STORE
            // extract from one lane of 128-bit register
            Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, index, esize];
            offs = offs + ebytes;
            t = (t + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



LD3R

Load single 3-element structure and Replicate to all lanes of three registers. This instruction loads a 3-element structure from memory and replicates the structure to all the lanes of the three SIMD&FP registers. Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

No offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	0	1	0	0	0	0	0	0	1	1	1	0	size	Rn				Rt						
L										R	opcode					S															

LD3R { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T> }, [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	1	1	0	Rm					1	1	1	0	size	Rn				Rt						
L										R	opcode					S															

Immediate offset (Rm == 11111)

LD3R { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T> }, [<Xn|SP>], <imm>

Register offset (Rm != 11111)

LD3R { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T> }, [<Xn|SP>], <Xm>

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

Assembler Symbols

- <Vt> Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	1D
11	1	2D

- <Vt2> Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.

- <Vt3> Is the name of the third SIMD&FP register to be transferred, encoded as "Rt" plus 2 modulo 32.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the post-index immediate offset, encoded in "size":
- | size | <imm> |
|------|-------|
| 00   | #3    |
| 01   | #6    |
| 10   | #12   |
| 11   | #24   |
- <Xm> Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

## Shared Decode

```
integer init_scale = UInt(opcode<2:1>);
integer scale = init_scale;
integer selem = UInt(opcode<0>:R) + 1;
boolean replicate = FALSE;
integer index;

case scale of
  when 3
    // load and replicate
    if L == '0' || S == '1' then UNDEFINED;
    scale = UInt(size);
    replicate = TRUE;
  when 0
    index = UInt(Q:S:size);    // B[0-15]
  when 1
    if size<0> == '1' then UNDEFINED;
    index = UInt(Q:S:size<1>); // H[0-7]
  when 2
    if size<1> == '1' then UNDEFINED;
    if size<0> == '0' then
      index = UInt(Q:S);    // S[0-3]
    else
      if S == '1' then UNDEFINED;
      index = UInt(Q);    // D[0-1]
      scale = 3;

MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << scale;
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(128) rval;
bits(esize) element;
constant integer ebytes = esize DIV 8;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
if replicate then
    // load and replicate to all elements
    for s = 0 to selem-1
        element = Mem[address+offs, ebytes, AccType_VEC];
        // replicate to fill 128- or 64-bit register
        V[t] = Replicate(element, datasize DIV esize);
        offs = offs + ebytes;
        t = (t + 1) MOD 32;
else
    // load/store one element per register
    for s = 0 to selem-1
        rval = V[t];
        if memop == MemOp_LOAD then
            // insert into one lane of 128-bit register
            Elem[rval, index, esize] = Mem[address+offs, ebytes, AccType_VEC];
            V[t] = rval;
        else // memop == MemOp_STORE
            // extract from one lane of 128-bit register
            Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, index, esize];
            offs = offs + ebytes;
            t = (t + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

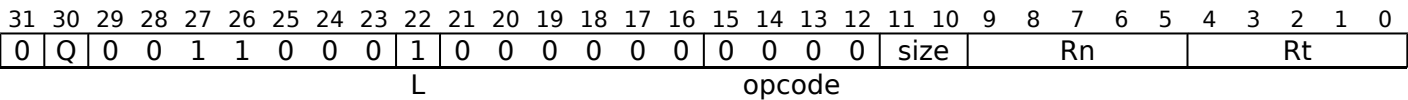
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

LD4 (multiple structures)

Load multiple 4-element structures to four registers. This instruction loads multiple 4-element structures from memory and writes the result to the four SIMD&FP registers, with de-interleaving.  
For an example of de-interleaving, see LD3 (multiple structures).  
Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: No offset and Post-index

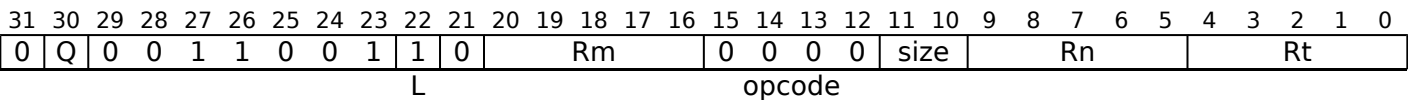
No offset



LD4 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T>, <Vt4>.<T> }, [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

Post-index



Immediate offset (Rm == 11111)

LD4 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T>, <Vt4>.<T> }, [<Xn|SP>], <imm>

Register offset (Rm != 11111)

LD4 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T>, <Vt4>.<T> }, [<Xn|SP>], <Xm>

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

Assembler Symbols

- <Vt> Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vt2> Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.

- <Vt3> Is the name of the third SIMD&FP register to be transferred, encoded as "Rt" plus 2 modulo 32.
- <Vt4> Is the name of the fourth SIMD&FP register to be transferred, encoded as "Rt" plus 3 modulo 32.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the post-index immediate offset, encoded in "Q":
 

Q	<imm>
0	#32
1	#64
- <Xm> Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

Shared Decode

```

MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << UInt(size);
integer elements = datasize DIV esize;

integer rpt;    // number of iterations
integer selem;  // structure elements

case opcode of
  when '0000' rpt = 1; selem = 4;    // LD/ST4 (4 registers)
  when '0010' rpt = 4; selem = 1;    // LD/ST1 (4 registers)
  when '0100' rpt = 1; selem = 3;    // LD/ST3 (3 registers)
  when '0110' rpt = 3; selem = 1;    // LD/ST1 (3 registers)
  when '0111' rpt = 1; selem = 1;    // LD/ST1 (1 register)
  when '1000' rpt = 1; selem = 2;    // LD/ST2 (2 registers)
  when '1010' rpt = 2; selem = 1;    // LD/ST1 (2 registers)
  otherwise UNDEFINED;

// .LD format only permitted with LD1 & ST1
if size:Q == '110' && selem != 1 then UNDEFINED;

```

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(datasize) rval;
integer tt;
constant integer ebytes = esize DIV 8;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
for r = 0 to rpt-1
    for e = 0 to elements-1
        tt = (t + r) MOD 32;
        for s = 0 to selem-1
            rval = V[tt];
            if memop == MemOp_LOAD then
                Elem[rval, e, esize] = Mem[address+offs, ebytes, AccType_VEC];
                V[tt] = rval;
            else // memop == MemOp_STORE
                Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, e, esize];
                offs = offs + ebytes;
                tt = (tt + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LD4 (single structure)

Load single 4-element structure to one lane of four registers. This instruction loads a 4-element structure from memory and writes the result to the corresponding elements of the four SIMD&FP registers without affecting the other bits of the registers.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

### No offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	0	1	1	0	0	0	0	0	x	x	1	S	size	Rn				Rt						
L										R										opcode											

### 8-bit (opcode == 001)

LD4 { <Vt>.B, <Vt2>.B, <Vt3>.B, <Vt4>.B }[<index>], [<Xn|SP>]

### 16-bit (opcode == 011 && size == x0)

LD4 { <Vt>.H, <Vt2>.H, <Vt3>.H, <Vt4>.H }[<index>], [<Xn|SP>]

### 32-bit (opcode == 101 && size == 00)

LD4 { <Vt>.S, <Vt2>.S, <Vt3>.S, <Vt4>.S }[<index>], [<Xn|SP>]

### 64-bit (opcode == 101 && S == 0 && size == 01)

LD4 { <Vt>.D, <Vt2>.D, <Vt3>.D, <Vt4>.D }[<index>], [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

### Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	1	1	1	Rm					x	x	1	S	size	Rn				Rt						
L										R	opcode																				

### 8-bit, immediate offset (Rm == 11111 && opcode == 001)

```
LD4 { <Vt>.B, <Vt2>.B, <Vt3>.B, <Vt4>.B }[<index>], [<Xn|SP>], #4
```

### 8-bit, register offset (Rm != 11111 && opcode == 001)

```
LD4 { <Vt>.B, <Vt2>.B, <Vt3>.B, <Vt4>.B }[<index>], [<Xn|SP>], <Xm>
```

### 16-bit, immediate offset (Rm == 11111 && opcode == 011 && size == x0)

```
LD4 { <Vt>.H, <Vt2>.H, <Vt3>.H, <Vt4>.H }[<index>], [<Xn|SP>], #8
```

### 16-bit, register offset (Rm != 11111 && opcode == 011 && size == x0)

```
LD4 { <Vt>.H, <Vt2>.H, <Vt3>.H, <Vt4>.H }[<index>], [<Xn|SP>], <Xm>
```

### 32-bit, immediate offset (Rm == 11111 && opcode == 101 && size == 00)

```
LD4 { <Vt>.S, <Vt2>.S, <Vt3>.S, <Vt4>.S }[<index>], [<Xn|SP>], #16
```

### 32-bit, register offset (Rm != 11111 && opcode == 101 && size == 00)

```
LD4 { <Vt>.S, <Vt2>.S, <Vt3>.S, <Vt4>.S }[<index>], [<Xn|SP>], <Xm>
```

### 64-bit, immediate offset (Rm == 11111 && opcode == 101 && S == 0 && size == 01)

```
LD4 { <Vt>.D, <Vt2>.D, <Vt3>.D, <Vt4>.D }[<index>], [<Xn|SP>], #32
```

### 64-bit, register offset (Rm != 11111 && opcode == 101 && S == 0 && size == 01)

```
LD4 { <Vt>.D, <Vt2>.D, <Vt3>.D, <Vt4>.D }[<index>], [<Xn|SP>], <Xm>
```

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

## Assembler Symbols

<Vt>	Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
<Vt2>	Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.
<Vt3>	Is the name of the third SIMD&FP register to be transferred, encoded as "Rt" plus 2 modulo 32.
<Vt4>	Is the name of the fourth SIMD&FP register to be transferred, encoded as "Rt" plus 3 modulo 32.
<index>	For the 8-bit variant: is the element index, encoded in "Q:S:size". For the 16-bit variant: is the element index, encoded in "Q:S:size<1>". For the 32-bit variant: is the element index, encoded in "Q:S". For the 64-bit variant: is the element index, encoded in "Q".
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.



## Shared Decode

```
integer init_scale = UInt(opcode<2:1>);
integer scale = init_scale;
integer selem = UInt(opcode<0>:R) + 1;
boolean replicate = FALSE;
integer index;

case scale of
  when 3
    // load and replicate
    if L == '0' || S == '1' then UNDEFINED;
    scale = UInt(size);
    replicate = TRUE;
  when 0
    index = UInt(Q:S:size);    // B[0-15]
  when 1
    if size<0> == '1' then UNDEFINED;
    index = UInt(Q:S:size<1>); // H[0-7]
  when 2
    if size<1> == '1' then UNDEFINED;
    if size<0> == '0' then
      index = UInt(Q:S);    // S[0-3]
    else
      if S == '1' then UNDEFINED;
      index = UInt(Q);    // D[0-1]
      scale = 3;
MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << scale;
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(128) rval;
bits(esize) element;
constant integer ebytes = esize DIV 8;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
if replicate then
    // load and replicate to all elements
    for s = 0 to selem-1
        element = Mem[address+offs, ebytes, AccType_VEC];
        // replicate to fill 128- or 64-bit register
        V[t] = Replicate(element, datasize DIV esize);
        offs = offs + ebytes;
        t = (t + 1) MOD 32;
else
    // load/store one element per register
    for s = 0 to selem-1
        rval = V[t];
        if memop == MemOp_LOAD then
            // insert into one lane of 128-bit register
            Elem[rval, index, esize] = Mem[address+offs, ebytes, AccType_VEC];
            V[t] = rval;
        else // memop == MemOp_STORE
            // extract from one lane of 128-bit register
            Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, index, esize];
            offs = offs + ebytes;
            t = (t + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

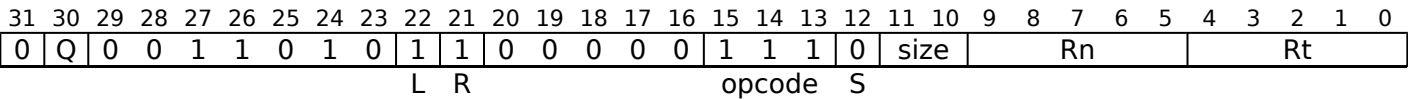
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

LD4R

Load single 4-element structure and Replicate to all lanes of four registers. This instruction loads a 4-element structure from memory and replicates the structure to all the lanes of the four SIMD&FP registers. Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: No offset and Post-index

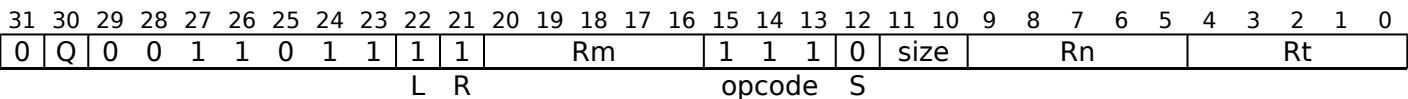
No offset



LD4R { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T>, <Vt4>.<T> }, [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

Post-index



Immediate offset (Rm == 11111)

LD4R { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T>, <Vt4>.<T> }, [<Xn|SP>], <imm>

Register offset (Rm != 11111)

LD4R { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T>, <Vt4>.<T> }, [<Xn|SP>], <Xm>

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

Assembler Symbols

- <Vt> Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	1D
11	1	2D

- <Vt2> Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.

- <Vt3> Is the name of the third SIMD&FP register to be transferred, encoded as "Rt" plus 2 modulo 32.
- <Vt4> Is the name of the fourth SIMD&FP register to be transferred, encoded as "Rt" plus 3 modulo 32.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the post-index immediate offset, encoded in "size":
 

size	<imm>
00	#4
01	#8
10	#16
11	#32
- <Xm> Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

Shared Decode

```

integer init_scale = UInt(opcode<2:1>);
integer scale = init_scale;
integer selem = UInt(opcode<0>:R) + 1;
boolean replicate = FALSE;
integer index;

case scale of
  when 3
    // load and replicate
    if L == '0' || S == '1' then UNDEFINED;
    scale = UInt(size);
    replicate = TRUE;
  when 0
    index = UInt(Q:S:size);    // B[0-15]
  when 1
    if size<0> == '1' then UNDEFINED;
    index = UInt(Q:S:size<1>);  // H[0-7]
  when 2
    if size<1> == '1' then UNDEFINED;
    if size<0> == '0' then
      index = UInt(Q:S);    // S[0-3]
    else
      if S == '1' then UNDEFINED;
      index = UInt(Q);    // D[0-1]
      scale = 3;

MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << scale;

```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(128) rval;
bits(esize) element;
constant integer ebytes = esize DIV 8;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
if replicate then
    // load and replicate to all elements
    for s = 0 to selem-1
        element = Mem[address+offs, ebytes, AccType_VEC];
        // replicate to fill 128- or 64-bit register
        V[t] = Replicate(element, datasize DIV esize);
        offs = offs + ebytes;
        t = (t + 1) MOD 32;
else
    // load/store one element per register
    for s = 0 to selem-1
        rval = V[t];
        if memop == MemOp_LOAD then
            // insert into one lane of 128-bit register
            Elem[rval, index, esize] = Mem[address+offs, ebytes, AccType_VEC];
            V[t] = rval;
        else // memop == MemOp_STORE
            // extract from one lane of 128-bit register
            Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, index, esize];
            offs = offs + ebytes;
            t = (t + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

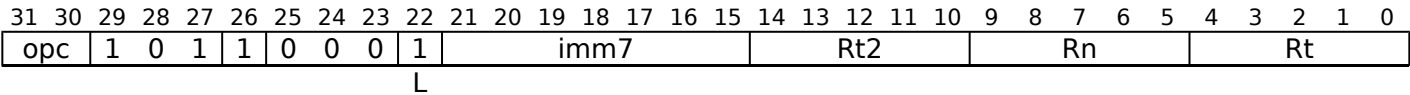
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDNP (SIMD&FP)

Load Pair of SIMD&FP registers, with Non-temporal hint. This instruction loads a pair of SIMD&FP registers from memory, issuing a hint to the memory system that the access is non-temporal. The address that is used for the load is calculated from a base register value and an optional immediate offset.

For information about non-temporal pair instructions, see [Load/Store SIMD and Floating-point Non-temporal pair](#). Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## 32-bit (opc == 00)

```
LDNP <St1>, <St2>, [<Xn|SP>{, #<imm>}]
```

## 64-bit (opc == 01)

```
LDNP <Dt1>, <Dt2>, [<Xn|SP>{, #<imm>}]
```

## 128-bit (opc == 10)

```
LDNP <Qt1>, <Qt2>, [<Xn|SP>{, #<imm>}]
```

```
// Empty.
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [LDNP \(SIMD&FP\)](#).

## Assembler Symbols

- <Dt1> Is the 64-bit name of the first SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Dt2> Is the 64-bit name of the second SIMD&FP register to be transferred, encoded in the "Rt2" field.
- <Qt1> Is the 128-bit name of the first SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Qt2> Is the 128-bit name of the second SIMD&FP register to be transferred, encoded in the "Rt2" field.
- <St1> Is the 32-bit name of the first SIMD&FP register to be transferred, encoded in the "Rt" field.
- <St2> Is the 32-bit name of the second SIMD&FP register to be transferred, encoded in the "Rt2" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> For the 32-bit variant: is the optional signed immediate byte offset, a multiple of 4 in the range -256 to 252, defaulting to 0 and encoded in the "imm7" field as <imm>/4.  
For the 64-bit variant: is the optional signed immediate byte offset, a multiple of 8 in the range -512 to 504, defaulting to 0 and encoded in the "imm7" field as <imm>/8.  
For the 128-bit variant: is the optional signed immediate byte offset, a multiple of 16 in the range -1024 to 1008, defaulting to 0 and encoded in the "imm7" field as <imm>/16.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer t2 = UInt(Rt2);
if opc == '11' then UNDEFINED;
integer scale = 2 + UInt(opc);
integer datasize = 8 << scale;
bits(64) offset = LSL(SignExtend(imm7, 64), scale);
boolean tag_checked = n != 31;

boolean rt_unknown = FALSE;

if t == t2 then
    Constraint c = ConstrainUnpredictable(Unpredictable_LDPOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rt_unknown = TRUE;    // result is UNKNOWN
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();
```

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(datasize) data1;
bits(datasize) data2;
constant integer dbytes = datasize DIV 8;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data1 = Mem[address, dbytes, AccType_VECSTREAM];
data2 = Mem[address+dbytes, dbytes, AccType_VECSTREAM];
if rt_unknown then
    data1 = bits(datasize) UNKNOWN;
    data2 = bits(datasize) UNKNOWN;
V[t] = data1;
V[t2] = data2;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

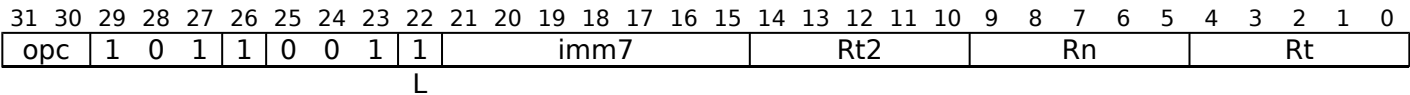
LDP (SIMD&FP)

Load Pair of SIMD&FP registers. This instruction loads a pair of SIMD&FP registers from memory. The address that is used for the load is calculated from a base register value and an optional immediate offset.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Signed offset](#)

Post-index



32-bit (opc == 00)

```
LDP <St1>, <St2>, [<Xn|SP>], #<imm>
```

64-bit (opc == 01)

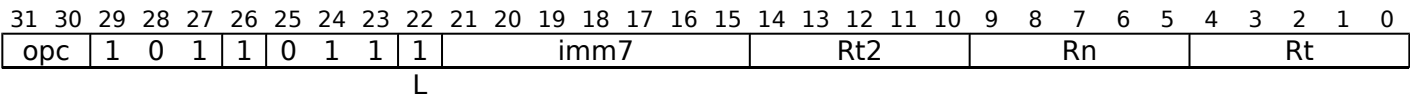
```
LDP <Dt1>, <Dt2>, [<Xn|SP>], #<imm>
```

128-bit (opc == 10)

```
LDP <Qt1>, <Qt2>, [<Xn|SP>], #<imm>
```

```
boolean wback = TRUE;
boolean postindex = TRUE;
```

Pre-index



32-bit (opc == 00)

```
LDP <St1>, <St2>, [<Xn|SP>, #<imm>]!
```

64-bit (opc == 01)

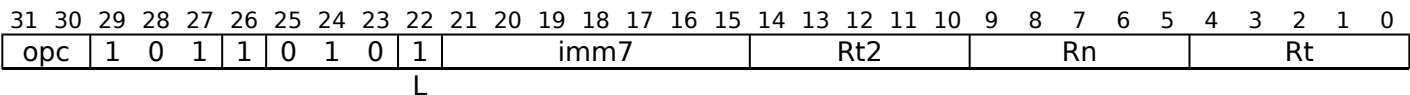
```
LDP <Dt1>, <Dt2>, [<Xn|SP>, #<imm>]!
```

128-bit (opc == 10)

```
LDP <Qt1>, <Qt2>, [<Xn|SP>, #<imm>]!
```

```
boolean wback = TRUE;
boolean postindex = FALSE;
```

Signed offset





### 32-bit (opc == 00)

```
LDP <St1>, <St2>, [<Xn|SP>{, #<imm>}]
```

### 64-bit (opc == 01)

```
LDP <Dt1>, <Dt2>, [<Xn|SP>{, #<imm>}]
```

### 128-bit (opc == 10)

```
LDP <Qt1>, <Qt2>, [<Xn|SP>{, #<imm>}]
```

```
boolean wback = FALSE;  
boolean postindex = FALSE;
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [LDP \(SIMD&FP\)](#).

## Assembler Symbols

<Dt1>	Is the 64-bit name of the first SIMD&FP register to be transferred, encoded in the "Rt" field.
<Dt2>	Is the 64-bit name of the second SIMD&FP register to be transferred, encoded in the "Rt2" field.
<Qt1>	Is the 128-bit name of the first SIMD&FP register to be transferred, encoded in the "Rt" field.
<Qt2>	Is the 128-bit name of the second SIMD&FP register to be transferred, encoded in the "Rt2" field.
<St1>	Is the 32-bit name of the first SIMD&FP register to be transferred, encoded in the "Rt" field.
<St2>	Is the 32-bit name of the second SIMD&FP register to be transferred, encoded in the "Rt2" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<imm>	For the 32-bit post-index and 32-bit pre-index variant: is the signed immediate byte offset, a multiple of 4 in the range -256 to 252, encoded in the "imm7" field as <imm>/4.  For the 32-bit signed offset variant: is the optional signed immediate byte offset, a multiple of 4 in the range -256 to 252, defaulting to 0 and encoded in the "imm7" field as <imm>/4.  For the 64-bit post-index and 64-bit pre-index variant: is the signed immediate byte offset, a multiple of 8 in the range -512 to 504, encoded in the "imm7" field as <imm>/8.  For the 64-bit signed offset variant: is the optional signed immediate byte offset, a multiple of 8 in the range -512 to 504, defaulting to 0 and encoded in the "imm7" field as <imm>/8.  For the 128-bit post-index and 128-bit pre-index variant: is the signed immediate byte offset, a multiple of 16 in the range -1024 to 1008, encoded in the "imm7" field as <imm>/16.  For the 128-bit signed offset variant: is the optional signed immediate byte offset, a multiple of 16 in the range -1024 to 1008, defaulting to 0 and encoded in the "imm7" field as <imm>/16.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer t2 = UInt(Rt2);
if opc == '11' then UNDEFINED;
integer scale = 2 + UInt(opc);
integer datasize = 8 << scale;
bits(64) offset = LSL(SignExtend(imm7, 64), scale);
boolean tag_checked = wback || n != 31;

boolean rt_unknown = FALSE;

if t == t2 then
    Constraint c = ConstrainUnpredictable(Unpredictable_LDPOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rt_unknown = TRUE;    // result is UNKNOWN
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();
```

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(datasize) data1;
bits(datasize) data2;
constant integer dbytes = datasize DIV 8;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

data1 = Mem[address, dbytes, AccType_VEC];
data2 = Mem[address+dbytes, dbytes, AccType_VEC];
if rt_unknown then
    data1 = bits(datasize) UNKNOWN;
    data2 = bits(datasize) UNKNOWN;
V[t] = data1;
V[t2] = data2;

if wback then
    if postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDR (immediate, SIMD&FP)

Load SIMD&FP Register (immediate offset). This instruction loads an element from memory, and writes the result as a scalar to the SIMD&FP register. The address that is used for the load is calculated from a base register value, a signed immediate offset, and an optional offset that is a multiple of the element size.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Unsigned offset](#)

## Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size	1	1	1	1	0	0	x	1	0	imm9										0	1	Rn					Rt				
opc																															

### 8-bit (size == 00 && opc == 01)

LDR <Bt>, [<Xn|SP>], #<sim>

### 16-bit (size == 01 && opc == 01)

LDR <Ht>, [<Xn|SP>], #<sim>

### 32-bit (size == 10 && opc == 01)

LDR <St>, [<Xn|SP>], #<sim>

### 64-bit (size == 11 && opc == 01)

LDR <Dt>, [<Xn|SP>], #<sim>

### 128-bit (size == 00 && opc == 11)

LDR <Qt>, [<Xn|SP>], #<sim>

```
boolean wback = TRUE;
boolean postindex = TRUE;
integer scale = UInt(opc<1>:size);
if scale > 4 then UNDEFINED;
bits(64) offset = SignExtend(imm9, 64);
```

## Pre-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size		1	1	1	1	0	0	x	1	0	imm9										1	1	Rn					Rt			
opc																															

8-bit (size == 00 && opc == 01)

```
LDR <Bt>, [<Xn|SP>, #<imm>]!
```

16-bit (size == 01 && opc == 01)

```
LDR <Ht>, [<Xn|SP>, #<imm>]!
```

32-bit (size == 10 && opc == 01)

```
LDR <St>, [<Xn|SP>, #<imm>]!
```

64-bit (size == 11 && opc == 01)

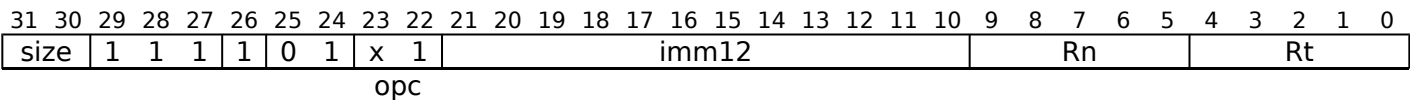
```
LDR <Dt>, [<Xn|SP>, #<imm>]!
```

128-bit (size == 00 && opc == 11)

```
LDR <Qt>, [<Xn|SP>, #<imm>]!
```

```
boolean wback = TRUE;
boolean postindex = FALSE;
integer scale = UInt(opc<1>:size);
if scale > 4 then UNDEFINED;
bits(64) offset = SignExtend(imm9, 64);
```

Unsigned offset



8-bit (size == 00 && opc == 01)

```
LDR <Bt>, [<Xn|SP>{, #<pimm>}]
```

16-bit (size == 01 && opc == 01)

```
LDR <Ht>, [<Xn|SP>{, #<pimm>}]
```

32-bit (size == 10 && opc == 01)

```
LDR <St>, [<Xn|SP>{, #<pimm>}]
```

64-bit (size == 11 && opc == 01)

```
LDR <Dt>, [<Xn|SP>{, #<pimm>}]
```

128-bit (size == 00 && opc == 11)

```
LDR <Qt>, [<Xn|SP>{, #<pimm>}]
```

```
boolean wback = FALSE;
boolean postindex = FALSE;
integer scale = UInt(opc<1>:size);
if scale > 4 then UNDEFINED;
bits(64) offset = LSL(ZeroExtend(imm12, 64), scale);
```

## Assembler Symbols

<Bt>	Is the 8-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
<Dt>	Is the 64-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
<Ht>	Is the 16-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
<Qt>	Is the 128-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
<St>	Is the 32-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<sim>	Is the signed immediate byte offset, in the range -256 to 255, encoded in the "imm9" field.
<pimm>	For the 8-bit variant: is the optional positive immediate byte offset, in the range 0 to 4095, defaulting to 0 and encoded in the "imm12" field.  For the 16-bit variant: is the optional positive immediate byte offset, a multiple of 2 in the range 0 to 8190, defaulting to 0 and encoded in the "imm12" field as <pimm>/2.  For the 32-bit variant: is the optional positive immediate byte offset, a multiple of 4 in the range 0 to 16380, defaulting to 0 and encoded in the "imm12" field as <pimm>/4.  For the 64-bit variant: is the optional positive immediate byte offset, a multiple of 8 in the range 0 to 32760, defaulting to 0 and encoded in the "imm12" field as <pimm>/8.  For the 128-bit variant: is the optional positive immediate byte offset, a multiple of 16 in the range 0 to 65520, defaulting to 0 and encoded in the "imm12" field as <pimm>/16.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
MemOp memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = 8 << scale;
boolean tag_checked = memop != MemOp_PREFETCH && (wback || n != 31);
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();
bits(64) address;
bits(datasize) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

case memop of
    when MemOp_STORE
        data = V[t];
        Mem[address, datasize DIV 8, AccType_VEC] = data;

    when MemOp_LOAD
        data = Mem[address, datasize DIV 8, AccType_VEC];
        V[t] = data;

if wback then
    if postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDR (literal, SIMD&FP)

Load SIMD&FP Register (PC-relative literal). This instruction loads a SIMD&FP register from memory. The address that is used for the load is calculated from the PC value and an immediate offset.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
opc		0	1	1	1	0	0	imm19																	Rt						

## 32-bit (opc == 00)

LDR <St>, <label>

## 64-bit (opc == 01)

LDR <Dt>, <label>

## 128-bit (opc == 10)

LDR <Qt>, <label>

```
integer t = UInt(Rt);
integer size;
bits(64) offset;

case opc of
  when '00'
    size = 4;
  when '01'
    size = 8;
  when '10'
    size = 16;
  when '11'
    UNDEFINED;

offset = SignExtend(imm19:'00', 64);
```

## Assembler Symbols

- <Dt> Is the 64-bit name of the SIMD&FP register to be loaded, encoded in the "Rt" field.
- <Qt> Is the 128-bit name of the SIMD&FP register to be loaded, encoded in the "Rt" field.
- <St> Is the 32-bit name of the SIMD&FP register to be loaded, encoded in the "Rt" field.
- <label> Is the program label from which the data is to be loaded. Its offset from the address of this instruction, in the range +/-1MB, is encoded as "imm19" times 4.

## Operation

```
bits(64) address = PC[] + offset;
bits(size*8) data;

if HaveMTE2Ext() then
  SetTagCheckedInstruction(FALSE);

CheckFPAdvSIMDEnabled64();

data = Mem[address, size, AccType_VEC];
V[t] = data;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



## LDR (register, SIMD&FP)

Load SIMD&FP Register (register offset). This instruction loads a SIMD&FP register from memory. The address that is used for the load is calculated from a base register value and an offset register value. The offset can be optionally shifted and extended.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0										
size		1		1		1		0		0		x		1		1		Rm						option		S		1		0		Rn						Rt			
opc																																									

### 8-fsreg,LDR-8-fsreg (size == 00 && opc == 01 && option != 011)

LDR <Bt>, [<Xn|SP>, (<Wm>|<Xm>), <extend> {<amount>}]

### 8-fsreg,LDR-8-fsreg (size == 00 && opc == 01 && option == 011)

LDR <Bt>, [<Xn|SP>, <Xm>{, LSL <amount>}]

### 16-fsreg,LDR-16-fsreg (size == 01 && opc == 01)

LDR <Ht>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]

### 32-fsreg,LDR-32-fsreg (size == 10 && opc == 01)

LDR <St>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]

### 64-fsreg,LDR-64-fsreg (size == 11 && opc == 01)

LDR <Dt>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]

### 128-fsreg,LDR-128-fsreg (size == 00 && opc == 11)

LDR <Qt>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]

```
integer scale = UInt(opc<1>:size);
if scale > 4 then UNDEFINED;
if option<1> == '0' then UNDEFINED;    // sub-word index
ExtendType extend_type = DecodeRegExtend(option);
integer shift = if S == '1' then scale else 0;
```

## Assembler Symbols

<Bt>	Is the 8-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
<Dt>	Is the 64-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
<Ht>	Is the 16-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
<Qt>	Is the 128-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
<St>	Is the 32-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<Wm>	When option<0> is set to 0, is the 32-bit name of the general-purpose index register, encoded in the "Rm" field.
<Xm>	When option<0> is set to 1, is the 64-bit name of the general-purpose index register, encoded in the "Rm" field.

<extend> For the 8-bit variant: is the index extend specifier, encoded in “option”:

option	<extend>
010	UXTW
110	SXTW
111	SCTX

For the 128-bit, 16-bit, 32-bit and 64-bit variant: is the index extend/shift specifier, defaulting to LSL, and which must be omitted for the LSL option when <amount> is omitted. encoded in “option”:

option	<extend>
010	UXTW
011	LSL
110	SXTW
111	SCTX

<amount> For the 8-bit variant: is the index shift amount, it must be #0, encoded in "S" as 0 if omitted, or as 1 if present.

For the 16-bit variant: is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in “S”:

S	<amount>
0	#0
1	#1

For the 32-bit variant: is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in “S”:

S	<amount>
0	#0
1	#2

For the 64-bit variant: is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in “S”:

S	<amount>
0	#0
1	#3

For the 128-bit variant: is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in “S”:

S	<amount>
0	#0
1	#4

Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer m = UInt(Rm);
MemOp memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = 8 << scale;
boolean tag_checked = memop != MemOp_PREFETCH;
```

## Operation

```
bits(64) offset = ExtendReg(m, extend_type, shift);
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();
bits(64) address;
bits(datasize) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

case memop of
    when MemOp_STORE
        data = V[t];
        Mem[address, datasize DIV 8, AccType_VEC] = data;

    when MemOp_LOAD
        data = Mem[address, datasize DIV 8, AccType_VEC];
        V[t] = data;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDUR (SIMD&FP)

Load SIMD&FP Register (unscaled offset). This instruction loads a SIMD&FP register from memory. The address that is used for the load is calculated from a base register value and an optional immediate offset.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size	1	1	1	1	0	0	x	1	0	imm9										0	0	Rn				Rt					
opc																															

## 8-bit (size == 00 && opc == 01)

LDUR <Bt>, [<Xn|SP>{, #<sim>}]

## 16-bit (size == 01 && opc == 01)

LDUR <Ht>, [<Xn|SP>{, #<sim>}]

## 32-bit (size == 10 && opc == 01)

LDUR <St>, [<Xn|SP>{, #<sim>}]

## 64-bit (size == 11 && opc == 01)

LDUR <Dt>, [<Xn|SP>{, #<sim>}]

## 128-bit (size == 00 && opc == 11)

LDUR <Qt>, [<Xn|SP>{, #<sim>}]

```
integer scale = UInt(opc<1>:size);
if scale > 4 then UNDEFINED;
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Bt> Is the 8-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Dt> Is the 64-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Ht> Is the 16-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Qt> Is the 128-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
- <St> Is the 32-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
MemOp memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = 8 << scale;
boolean tag_checked = memop != MemOp_PREFETCH && (n != 31);
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();
bits(64) address;
bits(datasize) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

case memop of
    when MemOp_STORE
        data = V[t];
        Mem[address, datasize DIV 8, AccType_VEC] = data;

    when MemOp_LOAD
        data = Mem[address, datasize DIV 8, AccType_VEC];
        V[t] = data;
```

## Operational information

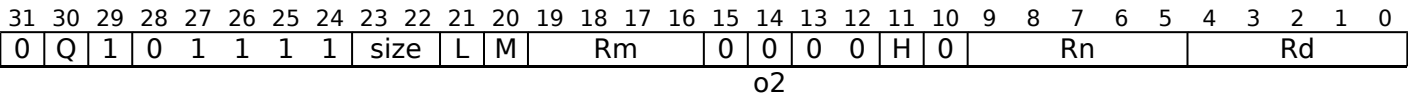
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

MLA (by element)

Multiply-Add to accumulator (vector, by element). This instruction multiplies the vector elements in the first source SIMD&FP register by the specified value in the second source SIMD&FP register, and accumulates the results with the vector elements of the destination SIMD&FP register. All the values in this instruction are unsigned integer values. Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



MLA <Vd>.<T>, <Vn>.<T>, <Vm>.<Ts>[<index>]

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
  when '01' index = UInt(H:L:M); Rmhi = '0';
  when '10' index = UInt(H:L); Rmhi = M;
  otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean sub_op = (o2 == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in "size:M:Rm":

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

Restricted to V0-V15 when element size <Ts> is H.

<Ts> Is an element size specifier, encoded in "size":

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in “size:L:H:M”:

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(idxdsize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
integer element1;
integer element2;
bits(esize) product;

element2 = UInt(Elem[operand2, index, esize]);
for e = 0 to elements-1
    element1 = UInt(Elem[operand1, e, esize]);
    product = (element1*element2)<esize-1:0>;
    if sub_op then
        Elem[result, e, esize] = Elem[operand3, e, esize] - product;
    else
        Elem[result, e, esize] = Elem[operand3, e, esize] + product;
V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

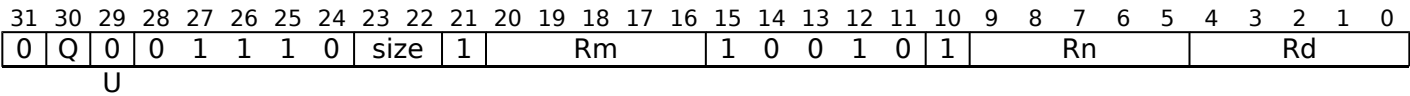
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# MLA (vector)

Multiply-Add to accumulator (vector). This instruction multiplies corresponding elements in the vectors of the two source SIMD&FP registers, and accumulates the results with the vector elements of the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



MLA <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean sub_op = (U == '1');
```

## Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;
bits(esize) product;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    product = (UInt(element1)*UInt(element2))<esize-1:0>;
    if sub_op then
        Elem[result, e, esize] = Elem[operand3, e, esize] - product;
    else
        Elem[result, e, esize] = Elem[operand3, e, esize] + product;
V[d] = result;
```



## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

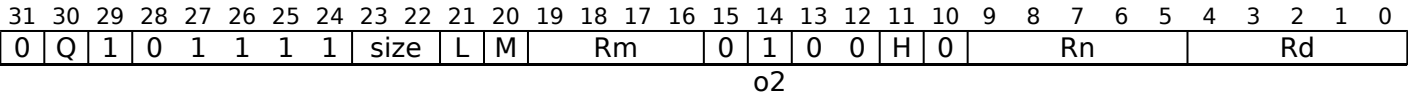
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

MLS (by element)

Multiply-Subtract from accumulator (vector, by element). This instruction multiplies the vector elements in the first source SIMD&FP register by the specified value in the second source SIMD&FP register, and subtracts the results from the vector elements of the destination SIMD&FP register. All the values in this instruction are unsigned integer values.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



MLS <Vd>.<T>, <Vn>.<T>, <Vm>.<Ts>[<index>]

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
  when '01' index = UInt(H:L:M); Rmhi = '0';
  when '10' index = UInt(H:L); Rmhi = M;
  otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean sub_op = (o2 == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in "size:M:Rm":

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

Restricted to V0-V15 when element size <Ts> is H.

<Ts> Is an element size specifier, encoded in "size":

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in “size:L:H:M”:

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(idxdsize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
integer element1;
integer element2;
bits(esize) product;

element2 = UInt(Elem[operand2, index, esize]);
for e = 0 to elements-1
    element1 = UInt(Elem[operand1, e, esize]);
    product = (element1*element2)<esize-1:0>;
    if sub_op then
        Elem[result, e, esize] = Elem[operand3, e, esize] - product;
    else
        Elem[result, e, esize] = Elem[operand3, e, esize] + product;
V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

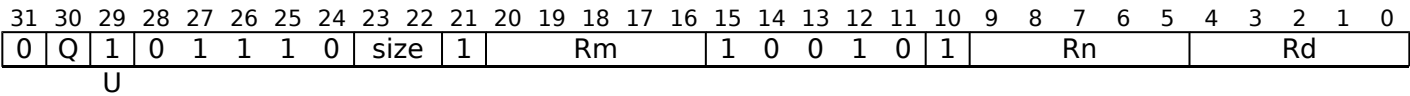
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# MLS (vector)

Multiply-Subtract from accumulator (vector). This instruction multiplies corresponding elements in the vectors of the two source SIMD&FP registers, and subtracts the results from the vector elements of the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



MLS <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean sub_op = (U == '1');
```

## Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;
bits(esize) product;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    product = (UInt(element1)*UInt(element2))<esize-1:0>;
    if sub_op then
        Elem[result, e, esize] = Elem[operand3, e, esize] - product;
    else
        Elem[result, e, esize] = Elem[operand3, e, esize] + product;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# MOV (scalar)

Move vector element to scalar. This instruction duplicates the specified vector element in the SIMD&FP source register into a scalar, and writes the result to the SIMD&FP destination register.  
Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This is an alias of [DUP \(element\)](#). This means:

- The encodings in this description are named to match the encodings of [DUP \(element\)](#).
- The description of [DUP \(element\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	0	0	imm5					0	0	0	0	0	1	Rn					Rd				

MOV <V><d>, <Vn>.<T>[<index>]

is equivalent to

DUP <V><d>, <Vn>.<T>[<index>]

and is always the preferred disassembly.

## Assembler Symbols

<V> Is the destination width specifier, encoded in “imm5”:

imm5	<V>
x0000	RESERVED
xxx1	B
xxx10	H
xx100	S
x1000	D

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<T> Is the element width specifier, encoded in “imm5”:

imm5	<T>
x0000	RESERVED
xxx1	B
xxx10	H
xx100	S
x1000	D

<index> Is the element index encoded in “imm5”:

imm5	<index>
x0000	RESERVED
xxx1	imm5<4:1>
xxx10	imm5<4:2>
xx100	imm5<4:3>
x1000	imm5<4>

## Operation

The description of [DUP \(element\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# MOV (element)

Move vector element to another vector element. This instruction copies the vector element of the source SIMD&FP register to the specified vector element of the destination SIMD&FP register.

This instruction can insert data into individual elements within a SIMD&FP register without clearing the remaining bits to zero.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This is an alias of [INS \(element\)](#). This means:

- The encodings in this description are named to match the encodings of [INS \(element\)](#).
- The description of [INS \(element\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	1	1	0	0	0	0	imm5					0	imm4				1	Rn					Rd				

MOV <Vd>.<Ts>[<index1>], <Vn>.<Ts>[<index2>]

is equivalent to

INS <Vd>.<Ts>[<index1>], <Vn>.<Ts>[<index2>]

and is always the preferred disassembly.

## Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ts> Is an element size specifier, encoded in "imm5":

imm5	<Ts>
x0000	RESERVED
xxxx1	B
xxx10	H
xx100	S
x1000	D

<index1> Is the destination element index encoded in "imm5":

imm5	<index1>
x0000	RESERVED
xxxx1	imm5<4:1>
xxx10	imm5<4:2>
xx100	imm5<4:3>
x1000	imm5<4>

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<index2> Is the source element index encoded in "imm5:imm4":

imm5	<index2>
x0000	RESERVED
xxxx1	imm4<3:0>
xxx10	imm4<3:1>
xx100	imm4<3:2>
x1000	imm4<3>

Unspecified bits in "imm4" are ignored but should be set to zero by an assembler.

## Operation

The description of [INS \(element\)](#) gives the operational pseudocode for this instruction.



## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# MOV (from general)

Move general-purpose register to a vector element. This instruction copies the contents of the source general-purpose register to the specified vector element in the destination SIMD&FP register.

This instruction can insert data into individual elements within a SIMD&FP register without clearing the remaining bits to zero.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This is an alias of *INS (general)*. This means:

- The encodings in this description are named to match the encodings of *INS (general)*.
- The description of *INS (general)* gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	1	1	1	0	0	0	0	imm5					0	0	0	1	1	1	Rn					Rd				

MOV <Vd>.<Ts>[<index>], <R><n>

is equivalent to

INS <Vd>.<Ts>[<index>], <R><n>

and is always the preferred disassembly.

## Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ts> Is an element size specifier, encoded in "imm5":

imm5	<Ts>
x0000	RESERVED
xxxx1	B
xxx10	H
xx100	S
x1000	D

<index> Is the element index encoded in "imm5":

imm5	<index>
x0000	RESERVED
xxxx1	imm5<4:1>
xxx10	imm5<4:2>
xx100	imm5<4:3>
x1000	imm5<4>

<R> Is the width specifier for the general-purpose source register, encoded in "imm5":

imm5	<R>
x0000	RESERVED
xxxx1	W
xxx10	W
xx100	W
x1000	X

<n> Is the number [0-30] of the general-purpose source register or ZR (31), encoded in the "Rn" field.

## Operation

The description of *INS (general)* gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

MOV (vector)

Move vector. This instruction copies the vector in the source SIMD&FP register into the destination SIMD&FP register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This is an alias of ORR (vector, register). This means:

- The encodings in this description are named to match the encodings of ORR (vector, register).
- The description of ORR (vector, register) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	0	1	Rm					0	0	0	1	1	1	Rn					Rd				
size																															

MOV <Vd>.<T>, <Vn>.<T>

is equivalent to

ORR <Vd>.<T>, <Vn>.<T>, <Vn>.<T>

and is the preferred disassembly when Rm == Rn.

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "Q":

Q	<T>
0	8B
1	16B

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

Operation

The description of ORR (vector, register) gives the operational pseudocode for this instruction.

Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# MOV (to general)

Move vector element to general-purpose register. This instruction reads the unsigned integer from the source SIMD&FP register, zero-extends it to form a 32-bit or 64-bit value, and writes the result to the destination general-purpose register.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This is an alias of *UMOV*. This means:

- The encodings in this description are named to match the encodings of *UMOV*.
  - The description of *UMOV* gives the operational pseudocode for this instruction.
- |      |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |   |   |   |    |   |   |   |   |
|------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|---|---|---|---|----|---|---|---|---|
| 31   | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9  | 8 | 7 | 6 | 5 | 4  | 3 | 2 | 1 | 0 |
| 0    | Q  | 0  | 0  | 1  | 1  | 1  | 0  | 0  | 0  | 0  | x  | x  | x  | 0  | 0  | 0  | 0  | 1  | 1  | 1  | 1  | Rn |   |   |   |   | Rd |   |   |   |   |
| imm5 |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |   |   |   |    |   |   |   |   |

## 32-bit (Q == 0 && imm5 == xx100)

*MOV* <Wd>, <Vn>.S[<index>]

is equivalent to

*UMOV* <Wd>, <Vn>.S[<index>]

and is always the preferred disassembly.

## 64-reg,UMOV-64-reg (Q == 1 && imm5 == x1000)

*MOV* <Xd>, <Vn>.D[<index>]

is equivalent to

*UMOV* <Xd>, <Vn>.D[<index>]

and is always the preferred disassembly.

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.
- <index> For the 32-bit variant: is the element index encoded in "imm5<4:3>".  
For the 64-reg,UMOV-64-reg variant: is the element index encoded in "imm5<4>".

## Operation

The description of *UMOV* gives the operational pseudocode for this instruction.

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.



## MOVI

Move Immediate (vector). This instruction places an immediate constant into every vector element of the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	op	0	1	1	1	1	0	0	0	0	0	a	b	c	cmode			0	1	d	e	f	g	h	Rd					

### 8-bit (op == 0 && cmode == 1110)

```
MOVI <Vd>.<T>, #<imm8>{, LSL #0}
```

### 16-bit shifted immediate (op == 0 && cmode == 10x0)

```
MOVI <Vd>.<T>, #<imm8>{, LSL #<amount>}
```

### 32-bit shifted immediate (op == 0 && cmode == 0xx0)

```
MOVI <Vd>.<T>, #<imm8>{, LSL #<amount>}
```

### 32-bit shifting ones (op == 0 && cmode == 110x)

```
MOVI <Vd>.<T>, #<imm8>, MSL #<amount>
```

### 64-bit scalar (Q == 0 && op == 1 && cmode == 1110)

```
MOVI <Dd>, #<imm>
```

### 64-bit vector (Q == 1 && op == 1 && cmode == 1110)

```
MOVI <Vd>.2D, #<imm>
```

```
integer rd = UInt(Rd);

integer datasize = if Q == '1' then 128 else 64;
bits(datasize) imm;
bits(64) imm64;

ImmediateOp operation;
case cmode:op of
  when '0xx00' operation = ImmediateOp_MOVI;
  when '0xx01' operation = ImmediateOp_MVNI;
  when '0xx10' operation = ImmediateOp_ORR;
  when '0xx11' operation = ImmediateOp_BIC;
  when '10x00' operation = ImmediateOp_MOVI;
  when '10x01' operation = ImmediateOp_MVNI;
  when '10x10' operation = ImmediateOp_ORR;
  when '10x11' operation = ImmediateOp_BIC;
  when '110x0' operation = ImmediateOp_MOVI;
  when '110x1' operation = ImmediateOp_MVNI;
  when '1110x' operation = ImmediateOp_MOVI;
  when '11110' operation = ImmediateOp_MOVI;
  when '11111'
    // FMOV Dn,#imm is in main FP instruction set
    if Q == '0' then UNDEFINED;
    operation = ImmediateOp_MOVI;

imm64 = AdvSIMDExpandImm(op, cmode, a:b:c:d:e:f:g:h);
imm = Replicate(imm64, datasize DIV 64);
```

Assembler Symbols

- <Dd>

Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <imm>

Is a 64-bit immediate 'aaaaaaaabbbbbbbccccccddddddeeeeeeffffffffggggggghhhhhhhh', encoded in "a:b:c:d:e:f:g:h".

<T> For the 8-bit variant: is an arrangement specifier, encoded in “Q”:

Q	<T>
0	8B
1	16B

For the 16-bit variant: is an arrangement specifier, encoded in “Q”:

Q	<T>
0	4H
1	8H

For the 32-bit variant: is an arrangement specifier, encoded in “Q”:

Q	<T>
0	2S
1	4S

<imm8> Is an 8-bit immediate encoded in "a:b:c:d:e:f:g:h".

<amount> For the 16-bit shifted immediate variant: is the shift amount encoded in “cmode<1>”:

cmode<1>	<amount>
0	0
1	8

defaulting to 0 if LSL is omitted.

For the 32-bit shifted immediate variant: is the shift amount encoded in “cmode<2:1>”:

cmode<2:1>	<amount>
00	0
01	8
10	16
11	24

defaulting to 0 if LSL is omitted.

For the 32-bit shifting ones variant: is the shift amount encoded in “cmode<0>”:

cmode<0>	<amount>
0	8
1	16



## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand;
bits(datasize) result;

case operation of
  when ImmediateOp_MOVI
    result = imm;
  when ImmediateOp_MVNI
    result = NOT(imm);
  when ImmediateOp_ORR
    operand = V[rd];
    result = operand OR imm;
  when ImmediateOp_BIC
    operand = V[rd];
    result = operand AND NOT(imm);

V[rd] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

MUL (by element)

Multiply (vector, by element). This instruction multiplies the vector elements in the first source SIMD&FP register by the specified value in the second source SIMD&FP register, places the results in a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are unsigned integer values.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	size	L	M	Rm				1	0	0	0	H	0	Rn				Rd						

MUL <Vd>.<T>, <Vn>.<T>, <Vm>.<Ts>[<index>]

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
  when '01' index = UInt(H:L:M); Rmhi = '0';
  when '10' index = UInt(H:L); Rmhi = M;
  otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in "size:M:Rm":

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

Restricted to V0-V15 when element size <Ts> is H.

<Ts> Is an element size specifier, encoded in "size":

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in “size:L:H:M”:

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(idxsize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
bits(esize) product;

element2 = UInt(Elem[operand2, index, esize]);
for e = 0 to elements-1
    element1 = UInt(Elem[operand1, e, esize]);
    product = (element1*element2)<esize-1:0>;
    Elem[result, e, esize] = product;

V[d] = result;
```

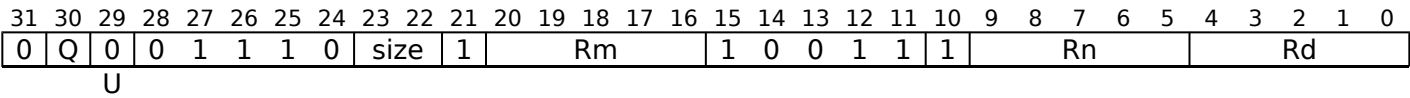
Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

MUL (vector)

Multiply (vector). This instruction multiplies corresponding elements in the vectors of the two source SIMD&FP registers, places the results in a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



MUL <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if U == '1' && size != '00' then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean poly = (U == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;
bits(esize) product;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    if poly then
        product = PolynomialMult(element1, element2)<esize-1:0>;
    else
        product = (UInt(element1)*UInt(element2))<esize-1:0>;
    Elem[result, e, esize] = product;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

MVN

Bitwise NOT (vector). This instruction reads each vector element from the source SIMD&FP register, places the inverse of each value into a vector, and writes the vector to the destination SIMD&FP register. Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This is an alias of NOT. This means:

- The encodings in this description are named to match the encodings of NOT.
- The description of NOT gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	0	1	0	0	0	0	0	0	1	0	1	1	0	Rn				Rd					

MVN <Vd>.<T>, <Vn>.<T>

is equivalent to

NOT <Vd>.<T>, <Vn>.<T>

and is always the preferred disassembly.

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "Q":

Q	<T>
0	8B
1	16B

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

The description of NOT gives the operational pseudocode for this instruction.

Operational information

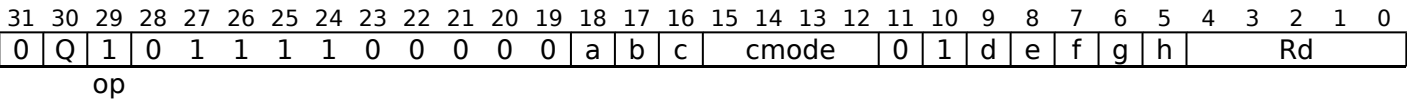
If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

MVNI

Move inverted Immediate (vector). This instruction places the inverse of an immediate constant into every vector element of the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



16-bit shifted immediate (cmode == 10x0)

```
MVNI <Vd>.<T>, #<imm8>{, LSL #<amount>}
```

32-bit shifted immediate (cmode == 0xx0)

```
MVNI <Vd>.<T>, #<imm8>{, LSL #<amount>}
```

32-bit shifting ones (cmode == 110x)

```
MVNI <Vd>.<T>, #<imm8>, MSL #<amount>
```

```
integer rd = UInt(Rd);

integer datasize = if Q == '1' then 128 else 64;
bits(datasize) imm;
bits(64) imm64;

ImmediateOp operation;
case cmode:op of
  when '0xx01' operation = ImmediateOp_MVNI;
  when '0xx11' operation = ImmediateOp_BIC;
  when '10x01' operation = ImmediateOp_MVNI;
  when '10x11' operation = ImmediateOp_BIC;
  when '110x1' operation = ImmediateOp_MVNI;
  when '1110x' operation = ImmediateOp_MOVI;
  when '11111'
    // FMOV Dn,#imm is in main FP instruction set
    if Q == '0' then UNDEFINED;
    operation = ImmediateOp_MOVI;

imm64 = AdvSIMDExpandImm(op, cmode, a:b:c:d:e:f:g:h);
imm = Replicate(imm64, datasize DIV 64);
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the 16-bit variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the 32-bit variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	2S
1	4S

<imm8> Is an 8-bit immediate encoded in "a:b:c:d:e:f:g:h".

<amount> For the 16-bit shifted immediate variant: is the shift amount encoded in “cmode<1>”:

cmode<1>	<amount>
0	0
1	8

defaulting to 0 if LSL is omitted.

For the 32-bit shifted immediate variant: is the shift amount encoded in “cmode<2:1>”:

cmode<2:1>	<amount>
00	0
01	8
10	16
11	24

defaulting to 0 if LSL is omitted.

For the 32-bit shifting ones variant: is the shift amount encoded in “cmode<0>”:

cmode<0>	<amount>
0	8
1	16

### Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand;
bits(datasize) result;

case operation of
  when ImmediateOp_MOVI
    result = imm;
  when ImmediateOp_MVNI
    result = NOT(imm);
  when ImmediateOp_ORR
    operand = V[rd];
    result = operand OR imm;
  when ImmediateOp_BIC
    operand = V[rd];
    result = operand AND NOT(imm);

V[rd] = result;
```

### Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

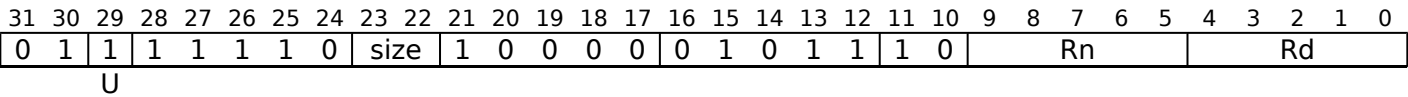


NEG (vector)

Negate (vector). This instruction reads each vector element from the source SIMD&FP register, negates each value, puts the result into a vector, and writes the vector to the destination SIMD&FP register.  
Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: Scalar and Vector

Scalar

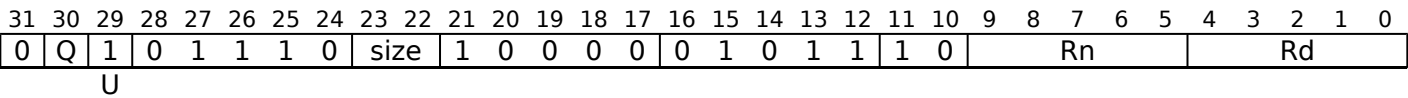


NEG <V><d>, <V><n>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean neg = (U == '1');
```

Vector



NEG <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean neg = (U == '1');
```

Assembler Symbols

- <V> Is a width specifier, encoded in “size”:
- | size | <V>      |
|------|----------|
| 0x   | RESERVED |
| 10   | RESERVED |
| 11   | D        |
- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
integer element;

for e = 0 to elements-1
    element = SInt(Elem[operand, e, esize]);
    if neg then
        element = -element;
    else
        element = Abs(element);
    Elem[result, e, esize] = element<esize-1:0>;

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# NOT

Bitwise NOT (vector). This instruction reads each vector element from the source SIMD&FP register, places the inverse of each value into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This instruction is used by the alias [MVN](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	0	1	0	0	0	0	0	0	1	0	1	1	0	Rn				Rd					

NOT <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 8;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV 8;
```

## Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "Q":

Q	<T>
0	8B
1	16B

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = NOT(element);

V[d] = result;
```

## Operational information

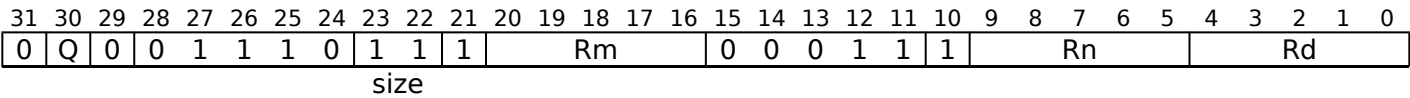
- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

ORN (vector)

Bitwise inclusive OR NOT (vector). This instruction performs a bitwise OR NOT between the two source SIMD&FP registers, and writes the result to the destination SIMD&FP register.  
Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



ORN <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if Q == '1' then 128 else 64;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "Q":

Q	<T>
0	8B
1	16B

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

operand2 = NOT(operand2);

result = operand1 OR operand2;

V[d] = result;
```

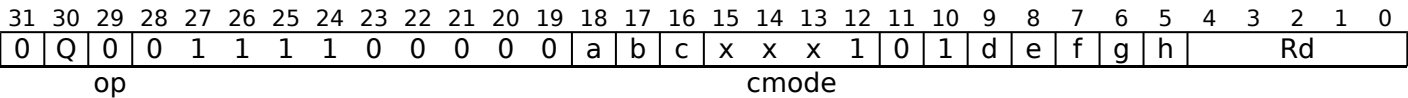
Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

ORR (vector, immediate)

Bitwise inclusive OR (vector, immediate). This instruction reads each vector element from the destination SIMD&FP register, performs a bitwise OR between each result and an immediate constant, places the result into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



16-bit (cmode == 10x1)

```
ORR <Vd>.<T>, #<imm8>{, LSL #<amount>}
```

32-bit (cmode == 0xx1)

```
ORR <Vd>.<T>, #<imm8>{, LSL #<amount>}
```

```
integer rd = UInt(Rd);

integer datasize = if Q == '1' then 128 else 64;
bits(datasize) imm;
bits(64) imm64;

ImmediateOp operation;
case cmode:op of
  when '0xx00' operation = ImmediateOp_MOVI;
  when '0xx10' operation = ImmediateOp_ORR;
  when '10x00' operation = ImmediateOp_MOVI;
  when '10x10' operation = ImmediateOp_ORR;
  when '110x0' operation = ImmediateOp_MOVI;
  when '1110x' operation = ImmediateOp_MOVI;
  when '11110' operation = ImmediateOp_MOVI;
imm64 = AdvSIMDExpandImm(op, cmode, a:b:c:d:e:f:g:h);
imm = Replicate(imm64, datasize DIV 64);
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP register, encoded in the "Rd" field.

<T> For the 16-bit variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the 32-bit variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	2S
1	4S

<imm8> Is an 8-bit immediate encoded in "a:b:c:d:e:f:g:h".

<amount> For the 16-bit variant: is the shift amount encoded in "cmode<1>":

cmode<1>	<amount>
0	0
1	8

defaulting to 0 if LSL is omitted.

For the 32-bit variant: is the shift amount encoded in “cmode<2:1>”:

cmode<2:1>	<amount>
00	0
01	8
10	16
11	24

defaulting to 0 if LSL is omitted.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand;
bits(datasize) result;

case operation of
  when ImmediateOp_MOVI
    result = imm;
  when ImmediateOp_MVNI
    result = NOT(imm);
  when ImmediateOp_ORR
    operand = V[rd];
    result = operand OR imm;
  when ImmediateOp_BIC
    operand = V[rd];
    result = operand AND NOT(imm);

V[rd] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

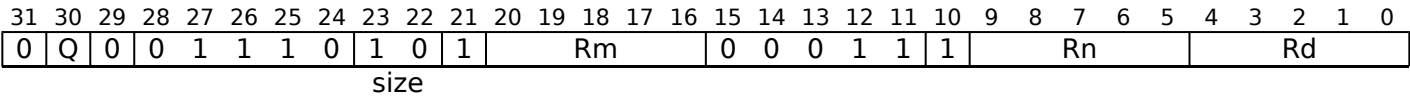
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

ORR (vector, register)

Bitwise inclusive OR (vector, register). This instruction performs a bitwise OR between the two source SIMD&FP registers, and writes the result to the destination SIMD&FP register.  
Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This instruction is used by the alias MOV (vector).



ORR <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if Q == '1' then 128 else 64;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "Q":

Q	<T>
0	8B
1	16B

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Alias Conditions

Alias	Is preferred when
MOV (vector)	Rm == Rn

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

result = operand1 OR operand2;
V[d] = result;
```

Operational information

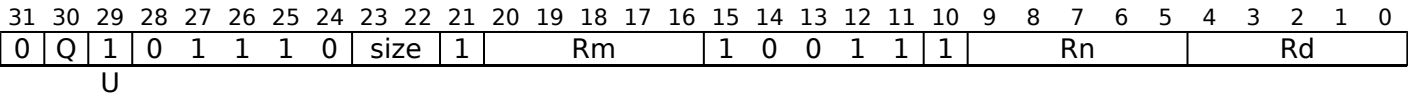
- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

PMUL

Polynomial Multiply. This instruction multiplies corresponding elements in the vectors of the two source SIMD&FP registers, places the results in a vector, and writes the vector to the destination SIMD&FP register.

For information about multiplying polynomials see *Polynomial arithmetic over {0, 1}*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



PMUL <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if U == '1' && size != '00' then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean poly = (U == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	x	RESERVED
1x	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;
bits(esize) product;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    if poly then
        product = PolynomialMult(element1, element2)<esize-1:0>;
    else
        product = (UInt(element1)*UInt(element2))<esize-1:0>;
    Elem[result, e, esize] = product;

V[d] = result;
```



## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

PMULL, PMULL2

Polynomial Multiply Long. This instruction multiplies corresponding elements in the lower or upper half of the vectors of the two source SIMD&FP registers, places the results in a vector, and writes the vector to the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied.

For information about multiplying polynomials see *Polynomial arithmetic over {0, 1}*.

The PMULL instruction extracts each source vector from the lower half of each source register, while the PMULL2 instruction extracts each source vector from the upper half of each source register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	Q	0	0	1	1	1	0	size	1	Rm						1	1	1	0	0	0	Rn						Rd					

PMULL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '01' || size == '10' then UNDEFINED;
if size == '11' && !HaveBit128PMULLExt() then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	RESERVED
10	RESERVED
11	1Q

The '1Q' arrangement is only allocated in an implementation that includes the Cryptographic Extension, and is otherwise RESERVED.

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	x	RESERVED
10	x	RESERVED
11	0	1D
11	1	2D

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    Elem[result, e, 2*esize] = PolynomialMult(element1, element2);

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

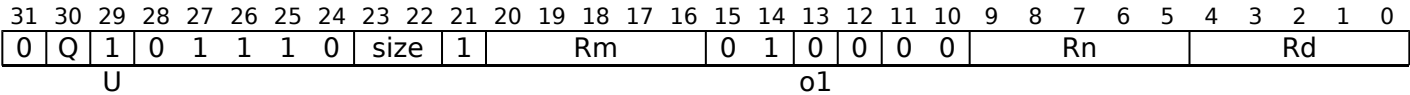
- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

RADDHN, RADDHN2

Rounding Add returning High Narrow. This instruction adds each vector element in the first source SIMD&FP register to the corresponding vector element in the second source SIMD&FP register, places the most significant half of the result into a vector, and writes the vector to the lower or upper half of the destination SIMD&FP register. The results are rounded. For truncated results, see [ADDHN](#). The RADDHN instruction writes the vector to the lower half of the destination register and clears the upper half, while the RADDHN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register. Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



RADDHN{2} <Vd>.<Tb>, <Vn>.<Ta>, <Vm>.<Ta>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean sub_op = (o1 == '1');
boolean round = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(2*datasize) operand1 = V[n];
bits(2*datasize) operand2 = V[m];
bits(datasize) result;
integer round_const = if round then 1 << (esize - 1) else 0;
bits(2*esize) element1;
bits(2*esize) element2;
bits(2*esize) sum;

for e = 0 to elements-1
    element1 = Elem[operand1, e, 2*esize];
    element2 = Elem[operand2, e, 2*esize];
    if sub_op then
        sum = element1 - element2;
    else
        sum = element1 + element2;
    sum = sum + round_const;
    Elem[result, e, esize] = sum<2*esize-1:esize>;

Vpart[d, part] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

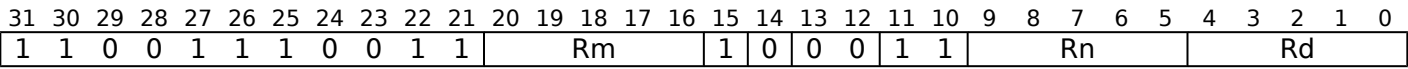
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

RAX1

Rotate and Exclusive OR rotates each 64-bit element of the 128-bit vector in a source SIMD&FP register left by 1, performs a bitwise exclusive OR of the resulting 128-bit vector and the vector in another source SIMD&FP register, and writes the result to the destination SIMD&FP register.

This instruction is implemented only when *FEAT\_SHA3* is implemented.

Advanced SIMD  
(FEAT\_SHA3)



RAX1 <Vd>.2D, <Vn>.2D, <Vm>.2D

```
if !HaveSHA3Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) Vm = V[m];
bits(128) Vn = V[n];
V[d] = Vn EOR (ROL(Vm<127:64>, 1):ROL(Vm<63:0>, 1));
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# RBIT (vector)

Reverse Bit order (vector). This instruction reads each vector element from the source SIMD&FP register, reverses the bits of the element, places the results into a vector, and writes the vector to the destination SIMD&FP register. Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	1	1	0	0	0	0	0	0	1	0	1	1	0	Rn				Rd					

RBIT <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 8;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV 8;
```

## Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "Q":

Q	<T>
0	8B
1	16B

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;
bits(esize) rev;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    for i = 0 to esize-1
        rev<esize-1-i> = element<i>;
    Elem[result, e, esize] = rev;

V[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

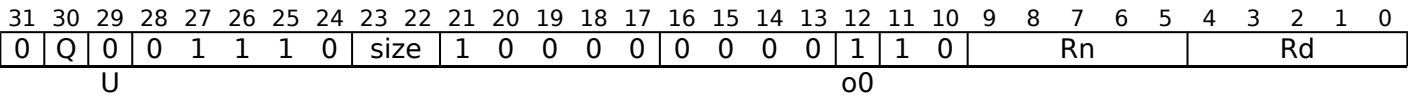
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

REV16 (vector)

Reverse elements in 16-bit halfwords (vector). This instruction reverses the order of 8-bit elements in each halfword of the vector in the source SIMD&FP register, places the results into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



REV16 <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

// size=esize:  B(0),  H(1),  S(1),  D(S)
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;

// op=REVx:  64(0), 32(1), 16(2)
bits(2) op = o0:U;

// => op+size:
//   64+B = 0, 64+H = 1, 64+S = 2, 64+D = X
//   32+B = 1, 32+H = 2, 32+S = X, 32+D = X
//   16+B = 2, 16+H = X, 16+S = X, 16+D = X
//   8+B = X, 8+H = X, 8+S = X, 8+D = X
// => 3-(op+size) (index bits in group)
//   64/B = 3, 64+H = 2, 64+S = 1, 64+D = X
//   32+B = 2, 32+H = 1, 32+S = X, 32+D = X
//   16+B = 1, 16+H = X, 16+S = X, 16+D = X
//   8+B = X, 8+H = X, 8+S = X, 8+D = X

// index bits within group: 1, 2, 3
if UInt(op) + UInt(size) >= 3 then UNDEFINED;

integer container_size;
case op of
  when '10' container_size = 16;
  when '01' container_size = 32;
  when '00' container_size = 64;

integer containers = datasize DIV container_size;
integer elements_per_container = container_size DIV esize;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	x	RESERVED
1x	x	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.



## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
integer element = 0;
integer rev_element;
for c = 0 to containers-1
    rev_element = element + elements_per_container - 1;
    for e = 0 to elements_per_container-1
        Elem[result, rev_element, esize] = Elem[operand, element, esize];
        element = element + 1;
        rev_element = rev_element - 1;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

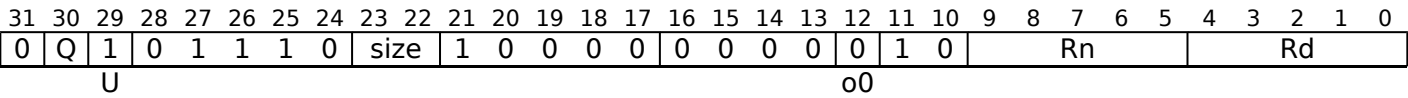
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

REV32 (vector)

Reverse elements in 32-bit words (vector). This instruction reverses the order of 8-bit or 16-bit elements in each word of the vector in the source SIMD&FP register, places the results into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



REV32 <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

// size=esize:  B(0),  H(1),  S(1), D(S)
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;

// op=REVx:  64(0), 32(1), 16(2)
bits(2) op = o0:U;

// => op+size:
//   64+B = 0, 64+H = 1, 64+S = 2, 64+D = X
//   32+B = 1, 32+H = 2, 32+S = X, 32+D = X
//   16+B = 2, 16+H = X, 16+S = X, 16+D = X
//   8+B = X, 8+H = X, 8+S = X, 8+D = X
// => 3-(op+size) (index bits in group)
//   64/B = 3, 64+H = 2, 64+S = 1, 64+D = X
//   32+B = 2, 32+H = 1, 32+S = X, 32+D = X
//   16+B = 1, 16+H = X, 16+S = X, 16+D = X
//   8+B = X, 8+H = X, 8+S = X, 8+D = X

// index bits within group: 1, 2, 3
if UInt(op) + UInt(size) >= 3 then UNDEFINED;

integer container_size;
case op of
  when '10' container_size = 16;
  when '01' container_size = 32;
  when '00' container_size = 64;

integer containers = datasize DIV container_size;
integer elements_per_container = container_size DIV esize;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
1x	x	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
integer element = 0;
integer rev_element;
for c = 0 to containers-1
    rev_element = element + elements_per_container - 1;
    for e = 0 to elements_per_container-1
        Elem[result, rev_element, esize] = Elem[operand, element, esize];
        element = element + 1;
        rev_element = rev_element - 1;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

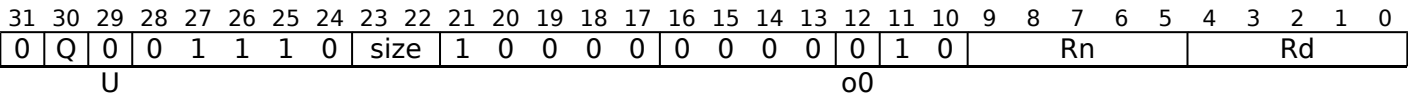
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

REV64

Reverse elements in 64-bit doublewords (vector). This instruction reverses the order of 8-bit, 16-bit, or 32-bit elements in each doubleword of the vector in the source SIMD&FP register, places the results into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



REV64 <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

// size=esize:  B(0),  H(1),  S(1),  D(S)
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;

// op=REVx:  64(0), 32(1), 16(2)
bits(2) op = o0:U;

// => op+size:
//   64+B = 0, 64+H = 1, 64+S = 2, 64+D = X
//   32+B = 1, 32+H = 2, 32+S = X, 32+D = X
//   16+B = 2, 16+H = X, 16+S = X, 16+D = X
//   8+B = X, 8+H = X, 8+S = X, 8+D = X
// => 3-(op+size) (index bits in group)
//   64/B = 3, 64+H = 2, 64+S = 1, 64+D = X
//   32+B = 2, 32+H = 1, 32+S = X, 32+D = X
//   16+B = 1, 16+H = X, 16+S = X, 16+D = X
//   8+B = X, 8+H = X, 8+S = X, 8+D = X

// index bits within group: 1, 2, 3
if UInt(op) + UInt(size) >= 3 then UNDEFINED;

integer container_size;
case op of
  when '10' container_size = 16;
  when '01' container_size = 32;
  when '00' container_size = 64;

integer containers = datasize DIV container_size;
integer elements_per_container = container_size DIV esize;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
integer element = 0;
integer rev_element;
for c = 0 to containers-1
    rev_element = element + elements_per_container - 1;
    for e = 0 to elements_per_container-1
        Elem[result, rev_element, esize] = Elem[operand, element, esize];
        element = element + 1;
        rev_element = rev_element - 1;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

RSHRN, RSHRN2

Rounding Shift Right Narrow (immediate). This instruction reads each unsigned integer value from the vector in the source SIMD&FP register, right shifts each result by an immediate value, writes the final result to a vector, and writes the vector to the lower or upper half of the destination SIMD&FP register. The destination vector elements are half as long as the source vector elements. The results are rounded. For truncated results, see [SHRN](#).

The RSHRN instruction writes the vector to the lower half of the destination register and clears the upper half, while the RSHRN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	0	!= 0000				immb			1	0	0	0	1	1	Rn						Rd			
immh										op																					

RSHRN{2} <Vd>.<Tb>, <Vn>.<Ta>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

integer shift = (2 * esize) - UInt(immh:immb);
boolean round = (op == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Tb> Is an arrangement specifier, encoded in “immh:Q”:

immh	Q	<Tb>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	x	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<Ta> Is an arrangement specifier, encoded in “immh”:

immh	<Ta>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	8H
001x	4S
01xx	2D
1xxx	RESERVED

<shift> Is the right shift amount, in the range 1 to the destination element width in bits, encoded in “immh:immb”:

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64\(\);
bits(datasize*2) operand = V[n];
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;

for e = 0 to elements-1
    element = (UInt(Elem[operand, e, 2*esize]) + round_const) >> shift;
    Elem[result, e, esize] = element<esize-1:0>;

Vpart[d, part] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

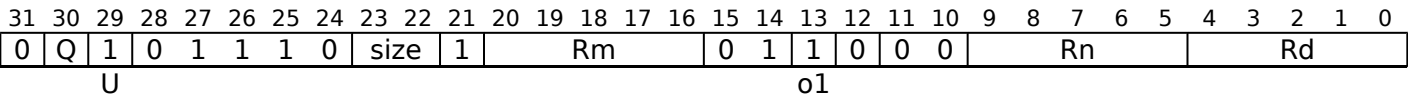
RSUBHN, RSUBHN2

Rounding Subtract returning High Narrow. This instruction subtracts each vector element of the second source SIMD&FP register from the corresponding vector element of the first source SIMD&FP register, places the most significant half of the result into a vector, and writes the vector to the lower or upper half of the destination SIMD&FP register.

The results are rounded. For truncated results, see [SUBHN](#).

The RSUBHN instruction writes the vector to the lower half of the destination register and clears the upper half, while the RSUBHN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



RSUBHN{2} <Vd>.<Tb>, <Vn>.<Ta>, <Vm>.<Ta>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean sub_op = (o1 == '1');
boolean round = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED



<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(2*datasize) operand1 = V[n];
bits(2*datasize) operand2 = V[m];
bits(datasize) result;
integer round_const = if round then 1 << (esize - 1) else 0;
bits(2*esize) element1;
bits(2*esize) element2;
bits(2*esize) sum;

for e = 0 to elements-1
    element1 = Elem[operand1, e, 2*esize];
    element2 = Elem[operand2, e, 2*esize];
    if sub_op then
        sum = element1 - element2;
    else
        sum = element1 + element2;
    sum = sum + round_const;
    Elem[result, e, esize] = sum<2*esize-1:esize>;

Vpart[d, part] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

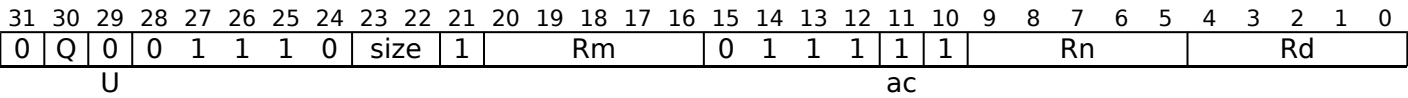
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SABA

Signed Absolute difference and Accumulate. This instruction subtracts the elements of the vector of the second source SIMD&FP register from the corresponding elements of the first source SIMD&FP register, and accumulates the absolute values of the results into the elements of the vector of the destination SIMD&FP register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



SABA <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean accumulate = (ac == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
bits(esize) absdiff;

result = if accumulate then V[d] else Zeros();
for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    absdiff = Abs(element1-element2)<esize-1:0>;
    Elem[result, e, esize] = Elem[result, e, esize] + absdiff;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

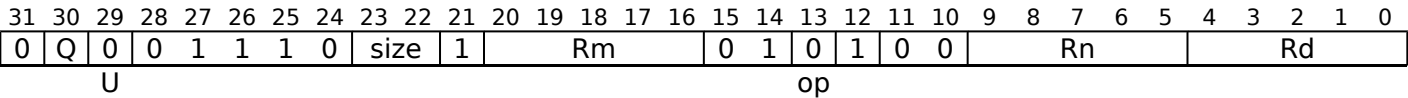
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SABAL, SABAL2

Signed Absolute difference and Accumulate Long. This instruction subtracts the vector elements in the lower or upper half of the second source SIMD&FP register from the corresponding vector elements of the first source SIMD&FP register, and accumulates the absolute values of the results into the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the source vector elements.

The SABAL instruction extracts each source vector from the lower half of each source register, while the SABAL2 instruction extracts each source vector from the upper half of each source register.

Depending on the settings in the CPACR EL1, CPTR EL2, and CPTR EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



SABAL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean accumulate = (op == '0');
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q 2	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) absdiff;

result = if accumulate then V[d] else Zeros();
for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    absdiff = Abs(element1-element2)<2*esize-1:0>;
    Elem[result, e, 2*esize] = Elem[result, e, 2*esize] + absdiff;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

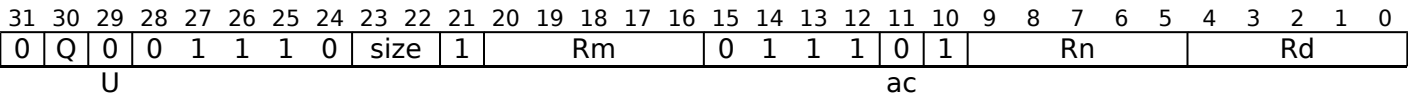
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SABD

Signed Absolute Difference. This instruction subtracts the elements of the vector of the second source SIMD&FP register from the corresponding elements of the first source SIMD&FP register, places the the absolute values of the results into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



SABD <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean accumulate = (ac == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
bits(esize) absdiff;

result = if accumulate then V[d] else Zeros();
for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    absdiff = Abs(element1-element2)<esize-1:0>;
    Elem[result, e, esize] = Elem[result, e, esize] + absdiff;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

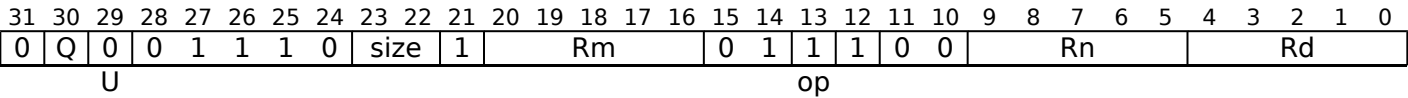
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SABDL, SABDL2

Signed Absolute Difference Long. This instruction subtracts the vector elements of the second source SIMD&FP register from the corresponding vector elements of the first source SIMD&FP register, places the absolute value of the results into a vector, and writes the vector to the lower or upper half of the destination SIMD&FP register. The destination vector elements are twice as long as the source vector elements.

The SABDL instruction writes the vector to the lower half of the destination register and clears the upper half, while the SABDL2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



SABDL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean accumulate = (op == '0');
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED



<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) absdiff;

result = if accumulate then V[d] else Zeros();
for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    absdiff = Abs(element1-element2)<2*esize-1:0>;
    Elem[result, e, 2*esize] = Elem[result, e, 2*esize] + absdiff;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

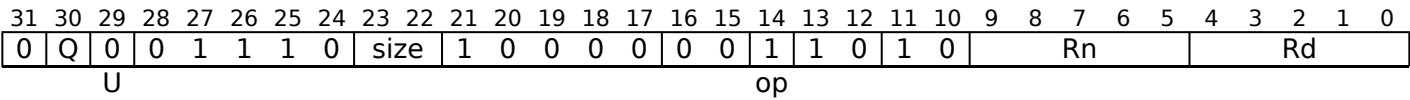
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SADALP

Signed Add and Accumulate Long Pairwise. This instruction adds pairs of adjacent signed integer values from the vector in the source SIMD&FP register and accumulates the results into the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the source vector elements.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



SADALP <Vd>.<Ta>, <Vn>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV (2 * esize);
boolean acc = (op == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in "size:Q":

size	Q	<Ta>
00	0	4H
00	1	8H
01	0	2S
01	1	4S
10	0	1D
10	1	2D
11	x	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in "size:Q":

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;

bits(2*esize) sum;
integer op1;
integer op2;

if acc then result = V[d];
for e = 0 to elements-1
    op1 = Int(Elem[operand, 2*e+0, esize], unsigned);
    op2 = Int(Elem[operand, 2*e+1, esize], unsigned);
    sum = (op1+op2)<2*esize-1:0>;
    if acc then
        Elem[result, e, 2*esize] = Elem[result, e, 2*esize] + sum;
    else
        Elem[result, e, 2*esize] = sum;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

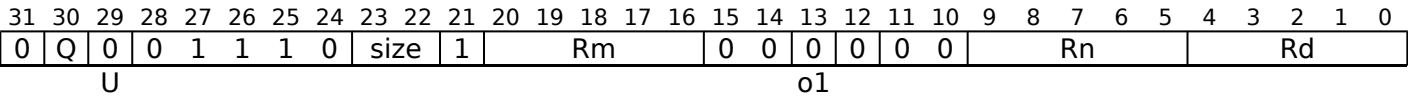
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SADDL, SADDL2

Signed Add Long (vector). This instruction adds each vector element in the lower or upper half of the first source SIMD&FP register to the corresponding vector element of the second source SIMD&FP register, places the results into a vector, and writes the vector to the destination SIMD&FP register. The destination vector elements are twice as long as the source vector elements. All the values in this instruction are signed integer values.

The SADDL instruction extracts each source vector from the lower half of each source register, while the SADDL2 instruction extracts each source vector from the upper half of each source register.

Depending on the settings in the CPACR EL1, CPTR EL2, and CPTR EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



SADDL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean sub_op = (o1 == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q 2	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
integer element1;
integer element2;
integer sum;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    if sub_op then
        sum = element1 - element2;
    else
        sum = element1 + element2;
    Elem[result, e, 2*esize] = sum<2*esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

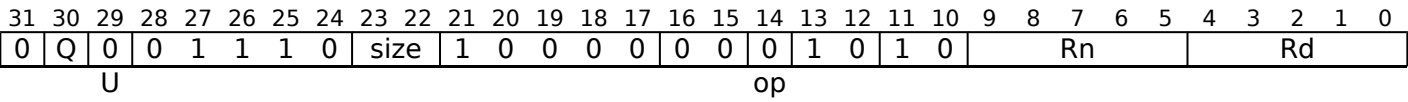
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SADDLP

Signed Add Long Pairwise. This instruction adds pairs of adjacent signed integer values from the vector in the source SIMD&FP register, places the result into a vector, and writes the vector to the destination SIMD&FP register. The destination vector elements are twice as long as the source vector elements.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



SADDLP <Vd>.<Ta>, <Vn>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV (2 * esize);
boolean acc = (op == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in "size:Q":

size	Q	<Ta>
00	0	4H
00	1	8H
01	0	2S
01	1	4S
10	0	1D
10	1	2D
11	x	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in "size:Q":

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;

bits(2*esize) sum;
integer op1;
integer op2;

if acc then result = V[d];
for e = 0 to elements-1
    op1 = Int(Elem[operand, 2*e+0, esize], unsigned);
    op2 = Int(Elem[operand, 2*e+1, esize], unsigned);
    sum = (op1+op2)<2*esize-1:0>;
    if acc then
        Elem[result, e, 2*esize] = Elem[result, e, 2*esize] + sum;
    else
        Elem[result, e, 2*esize] = sum;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

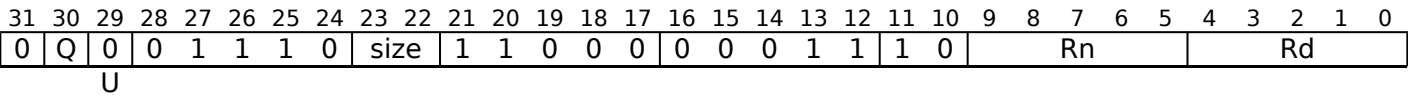
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SADDLV

Signed Add Long across Vector. This instruction adds every vector element in the source SIMD&FP register together, and writes the scalar result to the destination SIMD&FP register. The destination scalar is twice as long as the source vector elements. All the values in this instruction are signed integer values.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



SADDLV <V><d>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '100' then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
```

Assembler Symbols

<V> Is the destination width specifier, encoded in “size”:

size	<V>
00	H
01	S
10	D
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<T> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	RESERVED
10	1	4S
11	x	RESERVED

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
integer sum;

sum = Int(Elem[operand, 0, esize], unsigned);
for e = 1 to elements-1
    sum = sum + Int(Elem[operand, e, esize], unsigned);

V[d] = sum<2*esize-1:0>;
```



## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

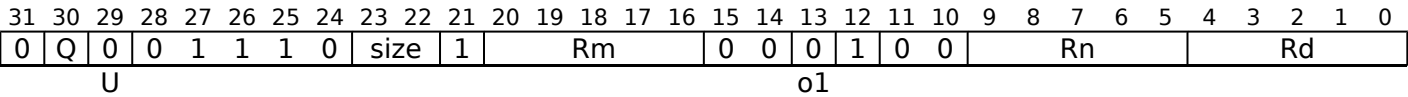
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SADDW, SADDW2

Signed Add Wide. This instruction adds vector elements of the first source SIMD&FP register to the corresponding vector elements in the lower or upper half of the second source SIMD&FP register, places the results in a vector, and writes the vector to the SIMD&FP destination register.

The SADDW instruction extracts the second source vector from the lower half of the second source register, while the SADDW2 instruction extracts the second source vector from the upper half of the second source register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



SADDW{2} <Vd>.<Ta>, <Vn>.<Ta>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean sub_op = (o1 == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q 2	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(2*datasize) operand1 = V[n];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
integer element1;
integer element2;
integer sum;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, 2*esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    if sub_op then
        sum = element1 - element2;
    else
        sum = element1 + element2;
    Elem[result, e, 2*esize] = sum<2*esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## SCVTF (vector, fixed-point)

Signed fixed-point Convert to Floating-point (vector). This instruction converts each element in a vector from fixed-point to floating-point using the rounding mode that is specified by the [FPCR](#), and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	0	!= 0000				immb			1	1	1	0	0	1	Rn				Rd					
U									immb																						

SCVTF <V><d>, <V><n>, #<fbits>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '000x' || (immh == '001x' && !HaveFP16Ext()) then UNDEFINED;
integer esize = if immh == '1xxx' then 64 else if immh == '01xx' then 32 else 16;
integer datasize = esize;
integer elements = 1;

integer fracbits = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
FPRounding rounding = FPRoundingMode(FPCR[]);
```

### Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	0	!= 0000				immb			1	1	1	0	0	1	Rn				Rd					
U									immb																						

SCVTF <Vd>.<T>, <Vn>.<T>, #<fbits>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh == '000x' || (immh == '001x' && !HaveFP16Ext()) then UNDEFINED;
if immh<3>:Q == '10' then UNDEFINED;
integer esize = if immh == '1xxx' then 64 else if immh == '01xx' then 32 else 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer fracbits = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
FPRounding rounding = FPRoundingMode(FPCR[]);
```

### Assembler Symbols

<V> Is a width specifier, encoded in “immh”:

immh	<V>
000x	RESERVED
001x	H
01xx	S
1xxx	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	x	RESERVED
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.
- <fbits> For the scalar variant: is the number of fractional bits, in the range 1 to the operand width, encoded in "immh:immb":

immh	<fbits>
000x	RESERVED
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

For the vector variant: is the number of fractional bits, in the range 1 to the element width, encoded in "immh:immb":

immh	<fbits>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	RESERVED
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];

bits(esize) element;
FPCRTYPE fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[d] else Zeros();

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FixedToFP(element, fracbits, unsigned, fpcr, rounding);
V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SCVTF (vector, integer)

Signed integer Convert to Floating-point (vector). This instruction converts each element in a vector from signed integer to floating-point using the rounding mode that is specified by the *FPCR*, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	1	1	1	1	0	0	1	1	1	0	1	1	0	Rn				Rd					
U																															

SCVTF <Hd>, <Hn>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
```

## Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	sz	1	0	0	0	0	1	1	1	0	1	1	0	Rn				Rd					
U																															

SCVTF <V><d>, <V><n>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
```

## Vector half precision (FEAT\_FP16)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	1	1	1	1	0	0	1	1	1	0	1	1	0	Rn				Rd					
U																															

SCVTF <Vd>.<T>, <Vn>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
```

## Vector single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	sz	1	0	0	0	0	1	1	1	0	1	1	0	Rn				Rd					
U																															

SCVTF <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
```

## Assembler Symbols

<Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.

<Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.

<V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];

FPCRType fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[d] else Zeros();

FPRounding rounding = FPRoundingMode(fpcr);
bits(esize) element;
for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FixedToFP(element, 0, unsigned, fpcr, rounding);

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

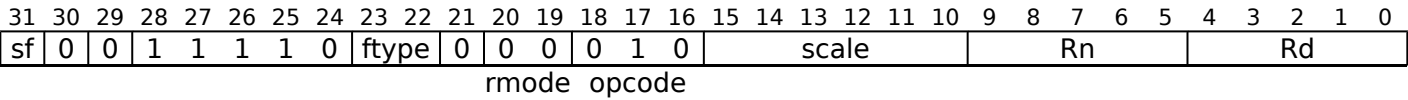


SCVTF (scalar, fixed-point)

Signed fixed-point Convert to Floating-point (scalar). This instruction converts the signed value in the 32-bit or 64-bit general-purpose source register to a floating-point value using the rounding mode that is specified by the *FPCR*, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.



**32-bit to half-precision (sf == 0 && ftype == 11)**  
(FEAT\_FP16)

SCVTF <Hd>, <Wn>, #<fbits>

**32-bit to single-precision (sf == 0 && ftype == 00)**

SCVTF <Sd>, <Wn>, #<fbits>

**32-bit to double-precision (sf == 0 && ftype == 01)**

SCVTF <Dd>, <Wn>, #<fbits>

**64-bit to half-precision (sf == 1 && ftype == 11)**  
(FEAT\_FP16)

SCVTF <Hd>, <Xn>, #<fbits>

**64-bit to single-precision (sf == 1 && ftype == 00)**

SCVTF <Sd>, <Xn>, #<fbits>

**64-bit to double-precision (sf == 1 && ftype == 01)**

SCVTF <Dd>, <Xn>, #<fbits>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;
FPRounding rounding;

case ftype of
  when '00' fltsize = 32;
  when '01' fltsize = 64;
  when '10' UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;

if sf == '0' && scale<5> == '0' then UNDEFINED;
integer fracbits = 64 - UInt(scale);

rounding = FPRoundingMode(FPCR[]);
```

## Assembler Symbols

<Dd>	Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Hd>	Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Sd>	Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
<fbits>	For the 32-bit to double-precision, 32-bit to half-precision and 32-bit to single-precision variant: is the number of bits after the binary point in the fixed-point source, in the range 1 to 32, encoded as 64 minus "scale".

For the 64-bit to double-precision, 64-bit to half-precision and 64-bit to single-precision variant: is the number of bits after the binary point in the fixed-point source, in the range 1 to 64, encoded as 64 minus "scale".

## Operation

```
CheckFPAdvSIMDEnabled64();

FPCRTYPE fpcr = FPCR[];
boolean merge = IsMerging(fpcr);
integer fsize = if merge then 128 else fltsize;
bits(fsize) fltval;
bits(intsize) intval;

intval = X[n];
fltval = if merge then V[d] else Zeros();
Elem[fltval, 0, fltsize] = FixedToFP(intval, fracbits, FALSE, fpcr, rounding);
V[d] = fltval;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

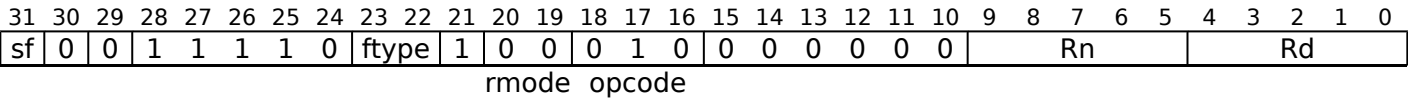
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SCVTF (scalar, integer)

Signed integer Convert to Floating-point (scalar). This instruction converts the signed integer value in the general-purpose source register to a floating-point value using the rounding mode that is specified by the *FPCR*, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



**32-bit to half-precision (sf == 0 && ftype == 11)**  
(FEAT\_FP16)

SCVTF <Hd>, <Wn>

**32-bit to single-precision (sf == 0 && ftype == 00)**

SCVTF <Sd>, <Wn>

**32-bit to double-precision (sf == 0 && ftype == 01)**

SCVTF <Dd>, <Wn>

**64-bit to half-precision (sf == 1 && ftype == 11)**  
(FEAT\_FP16)

SCVTF <Hd>, <Xn>

**64-bit to single-precision (sf == 1 && ftype == 00)**

SCVTF <Sd>, <Xn>

**64-bit to double-precision (sf == 1 && ftype == 01)**

SCVTF <Dd>, <Xn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;
FPRounding rounding;

case ftype of
  when '00'
    fltsize = 32;
  when '01'
    fltsize = 64;
  when '10'
    UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;

rounding = FPRoundingMode(FPCR[]);
```

## Assembler Symbols

<Dd>	Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Hd>	Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Sd>	Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
FPCRTyp fpcr = FPCR[];  
boolean merge = IsMerging(fpcr);  
integer fsize = if merge then 128 else fltsize;  
bits(fsize) fltval;  
bits(intsize) intval;  
  
intval = X[n];  
fltval = if merge then V[d] else Zeros();  
Elem[fltval, 0, fltsize] = FixedToFP(intval, 0, FALSE, fpcr, rounding);  
V[d] = fltval;
```

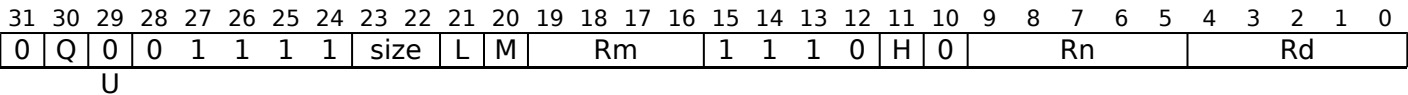
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SDOT (by element)

Dot Product signed arithmetic (vector, by element). This instruction performs the dot product of the four 8-bit elements in each 32-bit element of the first source register with the four 8-bit elements of an indexed 32-bit element in the second source register, accumulating the result into the corresponding 32-bit element of the destination register. Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped. In Armv8.2 and Armv8.3, this is an OPTIONAL instruction. From Armv8.4 it is mandatory for all implementations to support it. ID\_AA64ISAR0\_EL1.DP indicates whether this instruction is supported.

Vector (FEAT\_DotProd)



SDOT <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.4B[<index>]

```
if !HaveDOTPExt() then UNDEFINED;
if size != '10' then UNDEFINED;
boolean signed = (U == '0');

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(M:Rm);
integer index = UInt(H:L);

integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

- <Vd>

Is the name of the SIMD&FP third source and destination register, encoded in the "Rd" field.
- <Ta>

Is an arrangement specifier, encoded in "Q":

Q	<Ta>
0	2S
1	4S
- <Vn>

Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Tb>

Is an arrangement specifier, encoded in "Q":

Q	<Tb>
0	8B
1	16B
- <Vm>

Is the name of the second SIMD&FP source register, encoded in the "M:Rm" fields.
- <index>

Is the element index, encoded in the "H:L" fields.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(128) operand2 = V[m];
bits(datasize) result = V[d];
for e = 0 to elements-1
    integer res = 0;
    integer element1, element2;
    for i = 0 to 3
        if signed then
            element1 = SInt(Elem[operand1, 4*e+i, esize DIV 4]);
            element2 = SInt(Elem[operand2, 4*index+i, esize DIV 4]);
        else
            element1 = UInt(Elem[operand1, 4*e+i, esize DIV 4]);
            element2 = UInt(Elem[operand2, 4*index+i, esize DIV 4]);
        res = res + element1 * element2;
    Elem[result, e, esize] = Elem[result, e, esize] + res;
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



SDOT (vector)

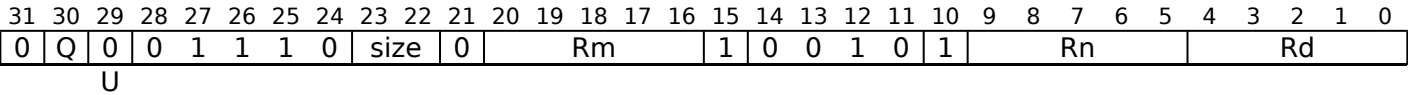
Dot Product signed arithmetic (vector). This instruction performs the dot product of the four signed 8-bit elements in each 32-bit element of the first source register with the four signed 8-bit elements of the corresponding 32-bit element in the second source register, accumulating the result into the corresponding 32-bit element of the destination register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

In Armv8.2 and Armv8.3, this is an OPTIONAL instruction. From Armv8.4 it is mandatory for all implementations to support it.

ID\_AA64ISAR0\_EL1.DP indicates whether this instruction is supported.

Vector  
(FEAT\_DotProd)



SDOT <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
if !HaveD0TPExt() then UNDEFINED;
if size != '10' then UNDEFINED;
boolean signed = (U == '0');
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP third source and destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in "Q":

Q	<Ta>
0	2S
1	4S

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in "Q":

Q	<Tb>
0	8B
1	16B

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

result = V[d];
for e = 0 to elements-1
    integer res = 0;
    integer element1, element2;
    for i = 0 to 3
        if signed then
            element1 = SInt(Elem[operand1, 4*e+i, esize DIV 4]);
            element2 = SInt(Elem[operand2, 4*e+i, esize DIV 4]);
        else
            element1 = UInt(Elem[operand1, 4*e+i, esize DIV 4]);
            element2 = UInt(Elem[operand2, 4*e+i, esize DIV 4]);
        res = res + element1 * element2;
    Elem[result, e, esize] = Elem[result, e, esize] + res;
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SHA1C

SHA1 hash update (choose).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	0	0	Rm				0	0	0	0	0	0	Rn				Rd						

SHA1C <Qd>, <Sn>, <Vm>.4S

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if !HaveSHA1Ext() then UNDEFINED;
```

Assembler Symbols

- <Qd> Is the 128-bit name of the SIMD&FP source and destination, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the third SIMD&FP source register, encoded in the "Rm" field.

Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) X = V[d];
bits(32) Y = V[n]; // Note: 32 not 128 bits wide
bits(128) W = V[m];
bits(32) t;

for e = 0 to 3
    t = SHAchoose(X<63:32>, X<95:64>, X<127:96>);
    Y = Y + ROL(X<31:0>, 5) + t + Elem[W, e, 32];
    X<63:32> = ROL(X<63:32>, 30);
    <Y, X> = ROL(Y:X, 32);
V[d] = X;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SHA1H

SHA1 fixed rotate.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	Rn					Rd				

SHA1H <Sd>, <Sn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
if !HaveSHA1Ext() then UNDEFINED;
```

## Assembler Symbols

- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(32) operand = V[n];    // read element [0] only, [1-3] zeroed
V[d] = ROL(operand, 30);
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

SHA1M

SHA1 hash update (majority).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	0	0	Rm				0	0	1	0	0	0	Rn				Rd						

SHA1M <Qd>, <Sn>, <Vm>.4S

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if !HaveSHA1Ext() then UNDEFINED;
```

Assembler Symbols

- <Qd> Is the 128-bit name of the SIMD&FP source and destination, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the third SIMD&FP source register, encoded in the "Rm" field.

Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) X = V[d];
bits(32) Y = V[n]; // Note: 32 not 128 bits wide
bits(128) W = V[m];
bits(32) t;

for e = 0 to 3
    t = SHAmajority(X<63:32>, X<95:64>, X<127:96>);
    Y = Y + ROL(X<31:0>, 5) + t + Elem[W, e, 32];
    X<63:32> = ROL(X<63:32>, 30);
    <Y, X> = ROL(Y:X, 32);
V[d] = X;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SHA1P

SHA1 hash update (parity).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	0	0	Rm					0	0	0	1	0	0	Rn					Rd				

SHA1P <Qd>, <Sn>, <Vm>.4S

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if !HaveSHA1Ext() then UNDEFINED;
```

## Assembler Symbols

- <Qd> Is the 128-bit name of the SIMD&FP source and destination, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the third SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) X = V[d];
bits(32) Y = V[n]; // Note: 32 not 128 bits wide
bits(128) W = V[m];
bits(32) t;

for e = 0 to 3
    t = SHAParity(X<63:32>, X<95:64>, X<127:96>);
    Y = Y + ROL(X<31:0>, 5) + t + Elem[W, e, 32];
    X<63:32> = ROL(X<63:32>, 30);
    <Y, X> = ROL(Y:X, 32);
V[d] = X;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SHA1SU0

SHA1 schedule update 0.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	0	0	Rm				0	0	1	1	0	0	Rn				Rd						

SHA1SU0 <Vd>.4S, <Vn>.4S, <Vm>.4S

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if !HaveSHA1Ext() then UNDEFINED;
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the second SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the third SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) operand1 = V[d];
bits(128) operand2 = V[n];
bits(128) operand3 = V[m];
bits(128) result;

result = operand2<63:0>:operand1<127:64>;
result = result EOR operand1 EOR operand3;
V[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SHA1SU1

SHA1 schedule update 1.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	0	1	0	1	0	0	0	0	0	0	1	1	0	Rn				Rd					

SHA1SU1 <Vd>.4S, <Vn>.4S

```
integer d = UInt(Rd);
integer n = UInt(Rn);
if !HaveSHA1Ext() then UNDEFINED;
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the second SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) operand1 = V[d];
bits(128) operand2 = V[n];
bits(128) result;
bits(128) T = operand1 EOR LSR(operand2, 32);
result<31:0> = ROL(T<31:0>, 1);
result<63:32> = ROL(T<63:32>, 1);
result<95:64> = ROL(T<95:64>, 1);
result<127:96> = ROL(T<127:96>, 1) EOR ROL(T<31:0>, 2);
V[d] = result;
```

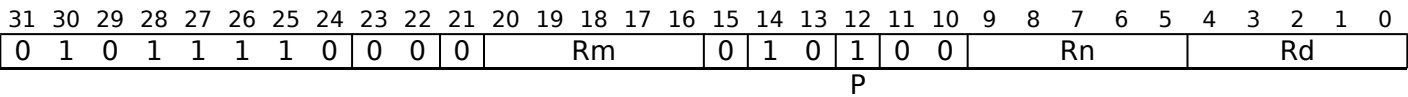
## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.



# SHA256H2

SHA256 hash update (part 2).



SHA256H2 <Qd>, <Qn>, <Vm>.4S

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if !HaveSHA256Ext() then UNDEFINED;
```

## Assembler Symbols

- <Qd> Is the 128-bit name of the SIMD&FP source and destination, encoded in the "Rd" field.
- <Qn> Is the 128-bit name of the second SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the third SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

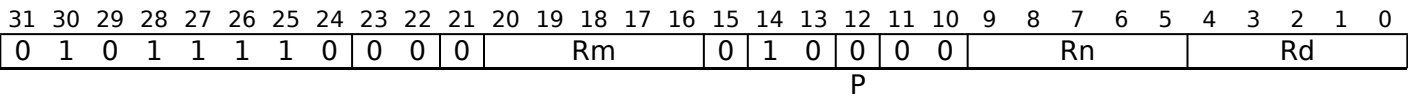
bits(128) result;
result = SHA256hash(V[n], V[d], V[m], FALSE);
V[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SHA256H

SHA256 hash update (part 1).



SHA256H <Qd>, <Qn>, <Vm>.4S

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if !HaveSHA256Ext() then UNDEFINED;
```

## Assembler Symbols

- <Qd> Is the 128-bit name of the SIMD&FP source and destination, encoded in the "Rd" field.
- <Qn> Is the 128-bit name of the second SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the third SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) result;
result = SHA256hash(V[d], V[n], V[m], TRUE);
V[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SHA256SU0

SHA256 schedule update 0.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	0	1	0	1	0	0	0	0	0	1	0	1	0	Rn				Rd					

SHA256SU0 <Vd>.4S, <Vn>.4S

```
integer d = UInt(Rd);
integer n = UInt(Rn);
if !HaveSHA256Ext() then UNDEFINED;
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the second SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) operand1 = V[d];
bits(128) operand2 = V[n];
bits(128) result;
bits(128) T = operand2<31:0>:operand1<127:32>;
bits(32) elt;

for e = 0 to 3
    elt = Elem[T, e, 32];
    elt = ROR(elt, 7) EOR ROR(elt, 18) EOR LSR(elt, 3);
    Elem[result, e, 32] = elt + Elem[operand1, e, 32];
V[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SHA256SU1

SHA256 schedule update 1.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	0	0	Rm					0	1	1	0	0	0	Rn					Rd				

SHA256SU1 <Vd>.4S, <Vn>.4S, <Vm>.4S

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if !HaveSHA256Ext() then UNDEFINED;
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the second SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the third SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) operand1 = V[d];
bits(128) operand2 = V[n];
bits(128) operand3 = V[m];
bits(128) result;
bits(128) T0 = operand3<31:0>:operand2<127:32>;
bits(64) T1;
bits(32) elt;

T1 = operand3<127:64>;
for e = 0 to 1
    elt = Elem[T1, e, 32];
    elt = ROR(elt, 17) EOR ROR(elt, 19) EOR LSR(elt, 10);
    elt = elt + Elem[operand1, e, 32] + Elem[T0, e, 32];
    Elem[result, e, 32] = elt;

T1 = result<63:0>;
for e = 2 to 3
    elt = Elem[T1, e-2, 32];
    elt = ROR(elt, 17) EOR ROR(elt, 19) EOR LSR(elt, 10);
    elt = elt + Elem[operand1, e, 32] + Elem[T0, e, 32];
    Elem[result, e, 32] = elt;

V[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SHA512H2

SHA512 Hash update part 2 takes the values from the three 128-bit source SIMD&FP registers and produces a 128-bit output value that combines the sigma0 and majority functions of two iterations of the SHA512 computation. It returns this value to the destination SIMD&FP register.

This instruction is implemented only when *FEAT\_SHA512* is implemented.

## Advanced SIMD (FEAT\_SHA512)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	1	1	Rm				1	0	0	0	0	1	Rn				Rd						

SHA512H2 <Qd>, <Qn>, <Vm>.2D

```
if !HaveSHA512Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
```

## Assembler Symbols

- <Qd> Is the 128-bit name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Qn> Is the 128-bit name of the second SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the third SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) Vtmp;
bits(64) NSigma0;
bits(128) X = V[n];
bits(128) Y = V[m];
bits(128) W = V[d];

NSigma0 = ROR(Y<63:0>, 28) EOR ROR(Y<63:0>, 34) EOR ROR(Y<63:0>, 39);
Vtmp<127:64> = (X<63:0> AND Y<127:64>) EOR (X<63:0> AND Y<63:0>) EOR (Y<127:64> AND Y<63:0>);
Vtmp<127:64> = (Vtmp<127:64> + NSigma0 + W<127:64>);
NSigma0 = ROR(Vtmp<127:64>, 28) EOR ROR(Vtmp<127:64>, 34) EOR ROR(Vtmp<127:64>, 39);
Vtmp<63:0> = (Vtmp<127:64> AND Y<63:0>) EOR (Vtmp<127:64> AND Y<127:64>) EOR (Y<127:64> AND Y<63:0>);
Vtmp<63:0> = (Vtmp<63:0> + NSigma0 + W<63:0>);

V[d] = Vtmp;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SHA512H

SHA512 Hash update part 1 takes the values from the three 128-bit source SIMD&FP registers and produces a 128-bit output value that combines the sigma1 and chi functions of two iterations of the SHA512 computation. It returns this value to the destination SIMD&FP register.

This instruction is implemented only when *FEAT\_SHA512* is implemented.

## Advanced SIMD (FEAT\_SHA512)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	1	1	Rm				1	0	0	0	0	0	Rn				Rd						

SHA512H <Qd>, <Qn>, <Vm>.2D

```
if !HaveSHA512Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
```

## Assembler Symbols

- <Qd> Is the 128-bit name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Qn> Is the 128-bit name of the second SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the third SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) Vtmp;
bits(64) MSigma1;
bits(64) tmp;
bits(128) X = V[n];
bits(128) Y = V[m];
bits(128) W = V[d];

MSigma1 = ROR(Y<127:64>, 14) EOR ROR(Y<127:64>, 18) EOR ROR(Y<127:64>, 41);
Vtmp<127:64> = (Y<127:64> AND X<63:0>) EOR (NOT(Y<127:64>) AND X<127:64>);
Vtmp<127:64> = (Vtmp<127:64> + MSigma1 + W<127:64>);
tmp = Vtmp<127:64> + Y<63:0>;
MSigma1 = ROR(tmp, 14) EOR ROR(tmp, 18) EOR ROR(tmp, 41);
Vtmp<63:0> = (tmp AND Y<127:64>) EOR (NOT(tmp) AND X<63:0>);
Vtmp<63:0> = (Vtmp<63:0> + MSigma1 + W<63:0>);
V[d] = Vtmp;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SHA512SU0

SHA512 Schedule Update 0 takes the values from the two 128-bit source SIMD&FP registers and produces a 128-bit output value that combines the gamma0 functions of two iterations of the SHA512 schedule update that are performed after the first 16 iterations within a block. It returns this value to the destination SIMD&FP register.

This instruction is implemented only when [FEAT\\_SHA512](#) is implemented.

## Advanced SIMD (FEAT\_SHA512)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	Rn				Rd					

SHA512SU0 <Vd>.2D, <Vn>.2D

```
if !HaveSHA512Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the second SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(64) sig0;
bits(128) Vtmp;
bits(128) X = V[n];
bits(128) W = V[d];
sig0 = ROR(W<127:64>, 1) EOR ROR(W<127:64>, 8) EOR ('0000000':W<127:71>);
Vtmp<63:0> = W<63:0> + sig0;
sig0 = ROR(X<63:0>, 1) EOR ROR(X<63:0>, 8) EOR ('0000000':X<63:7>);
Vtmp<127:64> = W<127:64> + sig0;
V[d] = Vtmp;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SHA512SU1

SHA512 Schedule Update 1 takes the values from the three source SIMD&FP registers and produces a 128-bit output value that combines the gamma1 functions of two iterations of the SHA512 schedule update that are performed after the first 16 iterations within a block. It returns this value to the destination SIMD&FP register.

This instruction is implemented only when *FEAT\_SHA512* is implemented.

## Advanced SIMD (FEAT\_SHA512)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	1	1	Rm				1	0	0	0	1	0	Rn				Rd						

SHA512SU1 <Vd>.2D, <Vn>.2D, <Vm>.2D

```
if !HaveSHA512Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the second SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the third SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(64) sig1;
bits(128) Vtmp;
bits(128) X = V[n];
bits(128) Y = V[m];
bits(128) W = V[d];

sig1 = ROR(X<127:64>, 19) EOR ROR(X<127:64>, 61) EOR ('000000':X<127:70>);
Vtmp<127:64> = W<127:64> + sig1 + Y<127:64>;
sig1 = ROR(X<63:0>, 19) EOR ROR(X<63:0>, 61) EOR ('000000':X<63:6>);
Vtmp<63:0> = W<63:0> + sig1 + Y<63:0>;
V[d] = Vtmp;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

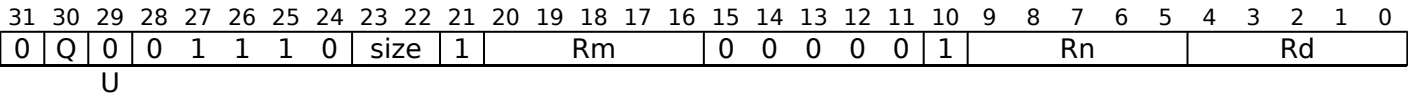


SHADD

Signed Halving Add. This instruction adds corresponding signed integer values from the two source SIMD&FP registers, shifts each result right one bit, places the results into a vector, and writes the vector to the destination SIMD&FP register.

The results are truncated. For rounded results, see [SRHADD](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



SHADD <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
integer sum;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    sum = element1 + element2;
    Elem[result, e, esize] = sum<esize:1>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SHL

Shift Left (immediate). This instruction reads each value from a vector, left shifts each result by an immediate value, writes the final result to a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	1	0	1	1	1	1	1	0	!= 0000				immb			0	1	0	1	0	1	1	Rn					Rd				
immh																																

SHL <V><d>, <V><n>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh<3> != '1' then UNDEFINED;
integer esize = 8 << 3;
integer datasize = esize;
integer elements = 1;

integer shift = UInt(immh:immb) - esize;
```

Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	0	!= 0000				immb			0	1	0	1	0	1	1	Rn				Rd				
immh																															

SHL <Vd>.<T>, <Vn>.<T>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3>:Q == '10' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer shift = UInt(immh:immb) - esize;
```

Assembler Symbols

<V> Is a width specifier, encoded in “immh”:

immh	<V>
0xxx	RESERVED
1xxx	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in “immh:Q”:

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<shift> For the scalar variant: is the left shift amount, in the range 0 to 63, encoded in "immh:immb":

immh	<shift>
0xxx	RESERVED
1xxx	(UInt(immh:immb) - 64)

For the vector variant: is the left shift amount, in the range 0 to the element width in bits minus 1, encoded in "immh:immb":

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(UInt(immh:immb) - 8)
001x	(UInt(immh:immb) - 16)
01xx	(UInt(immh:immb) - 32)
1xxx	(UInt(immh:immb) - 64)

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;

for e = 0 to elements-1
    Elem[result, e, esize] = LSL(Elem[operand, e, esize], shift);
V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SHLL, SHLL2

Shift Left Long (by element size). This instruction reads each vector element in the lower or upper half of the source SIMD&FP register, left shifts each result by the element size, writes the final result to a vector, and writes the vector to the destination SIMD&FP register. The destination vector elements are twice as long as the source vector elements. The SHLL instruction extracts vector elements from the lower half of the source register, while the SHLL2 instruction extracts vector elements from the upper half of the source register. Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	size				1	0	0	0	0	1	0	0	1	1	1	0	Rn				Rd			

SHLL{2} <Vd>.<Ta>, <Vn>.<Tb>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

integer shift = esize;
boolean unsigned = FALSE;    // Or TRUE without change of functionality
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q 2	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<shift> Is the left shift amount, which must be equal to the source element width in bits, encoded in “size”:

size	<shift>
00	8
01	16
10	32
11	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = Vpart[n, part];
bits(2*datasize) result;
integer element;

for e = 0 to elements-1
    element = Int(Elem[operand, e, esize], unsigned) << shift;
    Elem[result, e, 2*esize] = element<2*esize-1:0>;

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

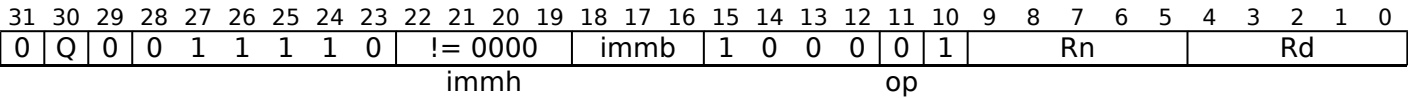
- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SHRN, SHRN2

Shift Right Narrow (immediate). This instruction reads each unsigned integer value from the source SIMD&FP register, right shifts each result by an immediate value, puts the final result into a vector, and writes the vector to the lower or upper half of the destination SIMD&FP register. The destination vector elements are half as long as the source vector elements. The results are truncated. For rounded results, see [RSHRN](#). The RSHRN instruction writes the vector to the lower half of the destination register and clears the upper half, while the RSHRN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register. Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



SHRN{2} <Vd>.<Tb>, <Vn>.<Ta>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

integer shift = (2 * esize) - UInt(immh:immb);
boolean round = (op == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Tb> Is an arrangement specifier, encoded in “immh:Q”:

immh	Q	<Tb>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	x	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<Ta> Is an arrangement specifier, encoded in “immh”:

immh	<Ta>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	8H
001x	4S
01xx	2D
1xxx	RESERVED

<shift> Is the right shift amount, in the range 1 to the destination element width in bits, encoded in “immh:immb”:

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64\(\);
bits(datasize*2) operand = V[n];
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;

for e = 0 to elements-1
    element = (UInt(Elem[operand, e, 2*esize]) + round_const) >> shift;
    Elem[result, e, esize] = element<esize-1:0>;

Vpart[d, part] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

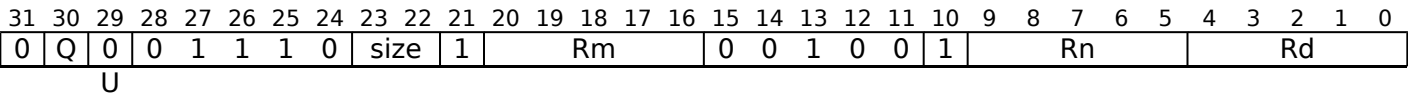
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



SHSUB

Signed Halving Subtract. This instruction subtracts the elements in the vector in the second source SIMD&FP register from the corresponding elements in the vector in the first source SIMD&FP register, shifts each result right one bit, places each result into elements of a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



SHSUB <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
integer diff;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    diff = element1 - element2;
    Elem[result, e, esize] = diff<esize:1>;

V[d] = result;
```

Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

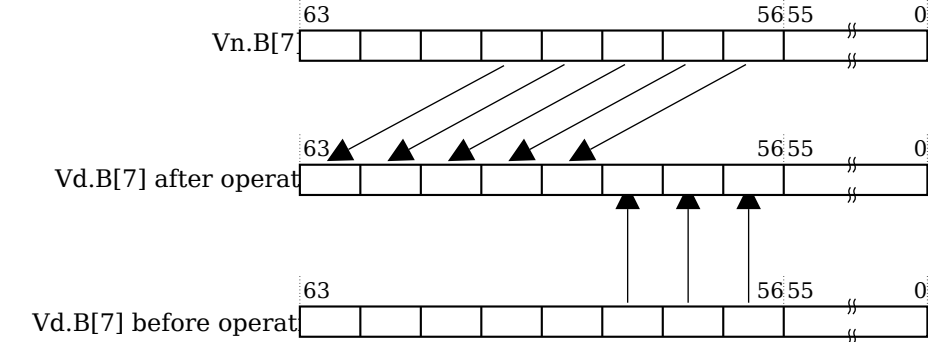
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SLI

Shift Left and Insert (immediate). This instruction reads each vector element in the source SIMD&FP register, left shifts each vector element by an immediate value, and inserts the result into the corresponding vector element in the destination SIMD&FP register such that the new zero bits created by the shift are not inserted but retain their existing value. Bits shifted out of the left of each vector element in the source register are lost.

The following figure shows an example of the operation of shift left by 3 for an 8-bit vector element.



Depending on the settings in the [CPACR EL1](#), [CPTR EL2](#), and [CPTR EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	1	0	!= 0000				immb			0	1	0	1	0	1	Rn			Rd						
immh																															

SLI <V><d>, <V><n>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh<3> != '1' then UNDEFINED;
integer esize = 8 << 3;
integer datasize = esize;
integer elements = 1;

integer shift = UInt(immh:immb) - esize;
```

Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	Q	1	0	1	1	1	1	0	!= 0000				immb			0	1	0	1	0	1	1	Rn					Rd				
immh																																

SLI <Vd>.<T>, <Vn>.<T>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3>:Q == '10' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer shift = UInt(immh:immb) - esize;
```

## Assembler Symbols

<V> Is a width specifier, encoded in “immh”:

immh	<V>
0xxx	RESERVED
1xxx	D

<d> Is the number of the SIMD&FP destination register, in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in “immh:Q”:

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<shift> For the scalar variant: is the left shift amount, in the range 0 to 63, encoded in “immh:immb”:

immh	<shift>
0xxx	RESERVED
1xxx	(UInt(immh:immb) - 64)

For the vector variant: is the left shift amount, in the range 0 to the element width in bits minus 1, encoded in “immh:immb”:

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(UInt(immh:immb) - 8)
001x	(UInt(immh:immb) - 16)
01xx	(UInt(immh:immb) - 32)
1xxx	(UInt(immh:immb) - 64)

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) operand2 = V[d];
bits(datasize) result;
bits(esize) mask = LSL(Ones(esize), shift);
bits(esize) shifted;

for e = 0 to elements-1
    shifted = LSL(Elem[operand, e, esize], shift);
    Elem[result, e, esize] = (Elem[operand2, e, esize] AND NOT(mask)) OR shifted;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:

- The values of the data supplied in any of its registers.
- The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SM3PARTW1

SM3PARTW1 takes three 128-bit vectors from the three source SIMD&FP registers and returns a 128-bit result in the destination SIMD&FP register. The result is obtained by a three-way exclusive OR of the elements within the input vectors with some fixed rotations, see the Operation pseudocode for more information.

This instruction is implemented only when [FEAT\\_SM3](#) is implemented.

## Advanced SIMD (FEAT\_SM3)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	1	1	Rm				1	1	0	0	0	0	Rn				Rd						

SM3PARTW1 <Vd>.4S, <Vn>.4S, <Vm>.4S

```
if !HaveSM3Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the second SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the third SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) Vm = V[m];
bits(128) Vn = V[n];
bits(128) Vd = V[d];
bits(128) result;

result<95:0> = (Vd EOR Vn)<95:0> EOR (ROL(Vm<127:96>, 15):ROL(Vm<95:64>, 15):ROL(Vm<63:32>, 15));

for i = 0 to 3
    if i == 3 then
        result<127:96> = (Vd EOR Vn)<127:96> EOR (ROL(result<31:0>, 15));
        result<(32*i)+31:(32*i)> = result<(32*i)+31:(32*i)> EOR ROL(result<(32*i)+31:(32*i)>, 15) EOR ROL(res
V[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SM3PARTW2

SM3PARTW2 takes three 128-bit vectors from three source SIMD&FP registers and returns a 128-bit result in the destination SIMD&FP register. The result is obtained by a three-way exclusive OR of the elements within the input vectors with some fixed rotations, see the Operation pseudocode for more information.

This instruction is implemented only when **FEAT\_SM3** is implemented.

## Advanced SIMD (FEAT\_SM3)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	1	1	Rm				1	1	0	0	0	1	Rn				Rd						

SM3PARTW2 <Vd>.4S, <Vn>.4S, <Vm>.4S

```
if !HaveSM3Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the second SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the third SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) Vm = V[m];
bits(128) Vn = V[n];
bits(128) Vd = V[d];
bits(128) result;
bits(128) tmp;
bits(32) tmp2;
tmp<127:0> = Vn EOR (ROL(Vm<127:96>, 7):ROL(Vm<95:64>, 7):ROL(Vm<63:32>, 7):ROL(Vm<31:0>, 7));
result<127:0> = Vd<127:0> EOR tmp<127:0>;
tmp2 = ROL(tmp<31:0>, 15);
tmp2 = tmp2 EOR ROL(tmp2, 15) EOR ROL(tmp2, 23);
result<127:96> = result<127:96> EOR tmp2;
V[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SM3SS1

SM3SS1 rotates the top 32 bits of the 128-bit vector in the first source SIMD&FP register by 12, and adds that 32-bit value to the two other 32-bit values held in the top 32 bits of each of the 128-bit vectors in the second and third source SIMD&FP registers, rotating this result left by 7 and writing the final result into the top 32 bits of the vector in the destination SIMD&FP register, with the bottom 96 bits of the vector being written to 0.

This instruction is implemented only when *FEAT\_SM3* is implemented.

## Advanced SIMD (FEAT\_SM3)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	1	0	Rm				0	Ra				Rn				Rd							

SM3SS1 <Vd>.4S, <Vn>.4S, <Vm>.4S, <Va>.4S

```
if !HaveSM3Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer a = UInt(Ra);
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Va> Is the name of the third SIMD&FP source register, encoded in the "Ra" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) Vm = V[m];
bits(128) Vn = V[n];
bits(128) Vd = V[d];
bits(128) Va = V[a];
Vd<127:96> = ROL((ROL(Vn<127:96>, 12) + Vm<127:96> + Va<127:96>), 7);
Vd<95:0> = Zeros();
V[d] = Vd;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.



# SM3TT1A

SM3TT1A takes three 128-bit vectors from three source SIMD&FP registers and a 2-bit immediate index value, and returns a 128-bit result in the destination SIMD&FP register. It performs a three-way exclusive OR of the three 32-bit fields held in the upper three elements of the first source vector, and adds the resulting 32-bit value and the following three other 32-bit values:

- The bottom 32-bit element of the first source vector, Vd, that was used for the three-way exclusive OR.
- The result of the exclusive OR of the top 32-bit element of the second source vector, Vn, with a rotation left by 12 of the top 32-bit element of the first source vector.
- A 32-bit element indexed out of the third source vector, Vm.

The result of this addition is returned as the top element of the result. The other elements of the result are taken from elements of the first source vector, with the element returned in bits<63:32> being rotated left by 9.

This instruction is implemented only when **FEAT\_SM3** is implemented.

## Advanced SIMD (FEAT\_SM3)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	1	0	Rm				1	0	imm2	0	0	Rn				Rd							

SM3TT1A <Vd>.4S, <Vn>.4S, <Vm>.S[<imm2>]

```
if !HaveSM3Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer i = UInt(imm2);
```

## Assembler Symbols

<Vd>	Is the name of the SIMD&FP source and destination register, encoded in the "Rd" field.
<Vn>	Is the name of the second SIMD&FP source register, encoded in the "Rn" field.
<Vm>	Is the name of the third SIMD&FP source register, encoded in the "Rm" field.
<imm2>	Is a 32-bit element indexed out of <Vm>, encoded in "imm2".

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) Vm = V[m];
bits(128) Vn = V[n];
bits(128) Vd = V[d];
bits(32) WjPrime;
bits(128) result;
bits(32) TT1;
bits(32) SS2;

WjPrime = Elem[Vm, i, 32];
SS2 = Vn<127:96> EOR ROL(Vd<127:96>, 12);
TT1 = Vd<63:32> EOR (Vd<127:96> EOR Vd<95:64>);
TT1 = (TT1+Vd<31:0>+SS2+WjPrime)<31:0>;
result<31:0> = Vd<63:32>;
result<63:32> = ROL(Vd<95:64>, 9);
result<95:64> = Vd<127:96>;
result<127:96> = TT1;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SM3TT1B

SM3TT1B takes three 128-bit vectors from three source SIMD&FP registers and a 2-bit immediate index value, and returns a 128-bit result in the destination SIMD&FP register. It performs a 32-bit majority function between the three 32-bit fields held in the upper three elements of the first source vector, and adds the resulting 32-bit value and the following three other 32-bit values:

- The bottom 32-bit element of the first source vector, Vd, that was used for the 32-bit majority function.
- The result of the exclusive OR of the top 32-bit element of the second source vector, Vn, with a rotation left by 12 of the top 32-bit element of the first source vector.
- A 32-bit element indexed out of the third source vector, Vm.

The result of this addition is returned as the top element of the result. The other elements of the result are taken from elements of the first source vector, with the element returned in bits<63:32> being rotated left by 9.

This instruction is implemented only when **FEAT\_SM3** is implemented.

## Advanced SIMD (FEAT\_SM3)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	1	0	Rm				1	0	imm2	0	1	Rn				Rd							

SM3TT1B <Vd>.4S, <Vn>.4S, <Vm>.S[<imm2>]

```
if !HaveSM3Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer i = UInt(imm2);
```

## Assembler Symbols

<Vd>	Is the name of the SIMD&FP source and destination register, encoded in the "Rd" field.
<Vn>	Is the name of the second SIMD&FP source register, encoded in the "Rn" field.
<Vm>	Is the name of the third SIMD&FP source register, encoded in the "Rm" field.
<imm2>	Is a 32-bit element indexed out of <Vm>, encoded in "imm2".

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) Vm = V[m];
bits(128) Vn = V[n];
bits(128) Vd = V[d];
bits(32) WjPrime;
bits(128) result;
bits(32) TT1;
bits(32) SS2;

WjPrime = Elem[Vm, i, 32];
SS2 = Vn<127:96> EOR ROL(Vd<127:96>, 12);
TT1 = (Vd<127:96> AND Vd<63:32>) OR (Vd<127:96> AND Vd<95:64>) OR (Vd<63:32> AND Vd<95:64>);
TT1 = (TT1+Vd<31:0>+SS2+WjPrime)<31:0>;
result<31:0> = Vd<63:32>;
result<63:32> = ROL(Vd<95:64>, 9);
result<95:64> = Vd<127:96>;
result<127:96> = TT1;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SM3TT2A

SM3TT2A takes three 128-bit vectors from three source SIMD&FP register and a 2-bit immediate index value, and returns a 128-bit result in the destination SIMD&FP register. It performs a three-way exclusive OR of the three 32-bit fields held in the upper three elements of the first source vector, and adds the resulting 32-bit value and the following three other 32-bit values:

- The bottom 32-bit element of the first source vector, Vd, that was used for the three-way exclusive OR.
- The 32-bit element held in the top 32 bits of the second source vector, Vn.
- A 32-bit element indexed out of the third source vector, Vm.

A three-way exclusive OR is performed of the result of this addition, the result of the addition rotated left by 9, and the result of the addition rotated left by 17. The result of this exclusive OR is returned as the top element of the returned result. The other elements of this result are taken from elements of the first source vector, with the element returned in bits<63:32> being rotated left by 19.

This instruction is implemented only when **FEAT\_SM3** is implemented.

## Advanced SIMD (FEAT\_SM3)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	1	0	Rm				1	0	imm2				1	0	Rn				Rd				

SM3TT2A <Vd>.4S, <Vn>.4S, <Vm>.S[<imm2>]

```
if !HaveSM3Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer i = UInt(imm2);
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the second SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the third SIMD&FP source register, encoded in the "Rm" field.
- <imm2> Is a 32-bit element indexed out of <Vm>, encoded in "imm2".

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) Vm = V[m];
bits(128) Vn = V[n];
bits(128) Vd = V[d];
bits(32) Wj;
bits(128) result;
bits(32) TT2;

Wj = Elem[Vm, i, 32];
TT2 = Vd<63:32> EOR (Vd<127:96> EOR Vd<95:64>);
TT2 = (TT2+Vd<31:0>+Vn<127:96>+Wj)<31:0>;

result<31:0> = Vd<63:32>;
result<63:32> = ROL(Vd<95:64>, 19);
result<95:64> = Vd<127:96>;
result<127:96> = TT2 EOR ROL(TT2, 9) EOR ROL(TT2, 17);
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SM3TT2B

SM3TT2B takes three 128-bit vectors from three source SIMD&FP registers, and a 2-bit immediate index value, and returns a 128-bit result in the destination SIMD&FP register. It performs a 32-bit majority function between the three 32-bit fields held in the upper three elements of the first source vector, and adds the resulting 32-bit value and the following three other 32-bit values:

- The bottom 32-bit element of the first source vector, Vd, that was used for the 32-bit majority function.
- The 32-bit element held in the top 32 bits of the second source vector, Vn.
- A 32-bit element indexed out of the third source vector, Vm.

A three-way exclusive OR is performed of the result of this addition, the result of the addition rotated left by 9, and the result of the addition rotated left by 17. The result of this exclusive OR is returned as the top element of the returned result. The other elements of this result are taken from elements of the first source vector, with the element returned in bits<63:32> being rotated left by 19.

This instruction is implemented only when **FEAT\_SM3** is implemented.

## Advanced SIMD (FEAT\_SM3)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	1	0	Rm				1	0	imm2		1	1	Rn				Rd						

SM3TT2B <Vd>.4S, <Vn>.4S, <Vm>.S[<imm2>]

```
if !HaveSM3Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer i = UInt(imm2);
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the second SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the third SIMD&FP source register, encoded in the "Rm" field.
- <imm2> Is a 32-bit element indexed out of <Vm>, encoded in "imm2".

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) Vm = V[m];
bits(128) Vn = V[n];
bits(128) Vd = V[d];
bits(32) Wj;
bits(128) result;
bits(32) TT2;

Wj = Elem[Vm, i, 32];
TT2 = (Vd<127:96> AND Vd<95:64>) OR (NOT(Vd<127:96>) AND Vd<63:32>);
TT2 = (TT2+Vd<31:0>+Vn<127:96>+Wj)<31:0>;

result<31:0> = Vd<63:32>;
result<63:32> = ROL(Vd<95:64>, 19);
result<95:64> = Vd<127:96>;
result<127:96> = TT2 EOR ROL(TT2, 9) EOR ROL(TT2, 17);
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# SM4E

SM4 Encode takes input data as a 128-bit vector from the first source SIMD&FP register, and four iterations of the round key held as the elements of the 128-bit vector in the second source SIMD&FP register. It encrypts the data by four rounds, in accordance with the SM4 standard, returning the 128-bit result to the destination SIMD&FP register. This instruction is implemented only when *FEAT\_SM4* is implemented.

## Advanced SIMD (FEAT\_SM4)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	1	1	0	0	0	0	0	0	1	0	0	0	0	1	0	Rn				Rd				

SM4E <Vd>.4S, <Vn>.4S

```
if !HaveSM4Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the second SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) Vn = V[n];
bits(32) intval;
bits(8) sboxout;
bits(128) roundresult;
bits(32) roundkey;

roundresult = V[d];
for index = 0 to 3
    roundkey = Elem[Vn, index, 32];

    intval = roundresult<127:96> EOR roundresult<95:64> EOR roundresult<63:32> EOR roundkey;

    for i = 0 to 3
        Elem[intval, i, 8] = Sbox(Elem[intval, i, 8]);

    intval = intval EOR ROL(intval, 2) EOR ROL(intval, 10) EOR ROL(intval, 18) EOR ROL(intval, 24);
    intval = intval EOR roundresult<31:0>;

    roundresult<31:0> = roundresult<63:32>;
    roundresult<63:32> = roundresult<95:64>;
    roundresult<95:64> = roundresult<127:96>;
    roundresult<127:96> = intval;
V[d] = roundresult;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.



# SM4EKEY

SM4 Key takes an input as a 128-bit vector from the first source SIMD&FP register and a 128-bit constant from the second SIMD&FP register. It derives four iterations of the output key, in accordance with the SM4 standard, returning the 128-bit result to the destination SIMD&FP register.

This instruction is implemented only when *FEAT\_SM4* is implemented.

## Advanced SIMD (FEAT\_SM4)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	1	1	Rm				1	1	0	0	1	0	Rn				Rd						

SM4EKEY <Vd>.4S, <Vn>.4S, <Vm>.4S

```
if !HaveSM4Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) Vm = V[m];
bits(32) intval;
bits(8) sboxout;
bits(128) result;
bits(32) const;
bits(128) roundresult;

roundresult = V[n];
for index = 0 to 3
    const = Elem[Vm, index, 32];

    intval = roundresult<127:96> EOR roundresult<95:64> EOR roundresult<63:32> EOR const;

    for i = 0 to 3
        Elem[intval, i, 8] = Sbox(Elem[intval, i, 8]);

    intval = intval EOR ROL(intval, 13) EOR ROL(intval, 23);
    intval = intval EOR roundresult<31:0>;

    roundresult<31:0> = roundresult<63:32>;
    roundresult<63:32> = roundresult<95:64>;
    roundresult<95:64> = roundresult<127:96>;
    roundresult<127:96> = intval;
V[d] = roundresult;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

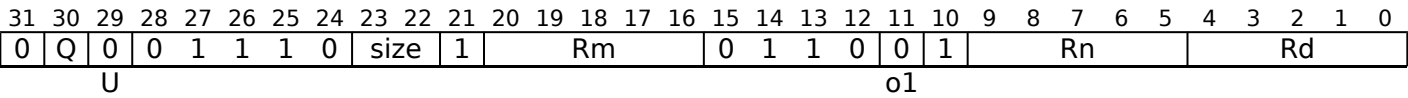
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SMAX

Signed Maximum (vector). This instruction compares corresponding elements in the vectors in the two source SIMD&FP registers, places the larger of each pair of signed integer values into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



SMAX <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean minimum = (o1 == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
integer maxmin;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    maxmin = if minimum then Min(element1, element2) else Max(element1, element2);
    Elem[result, e, esize] = maxmin<esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

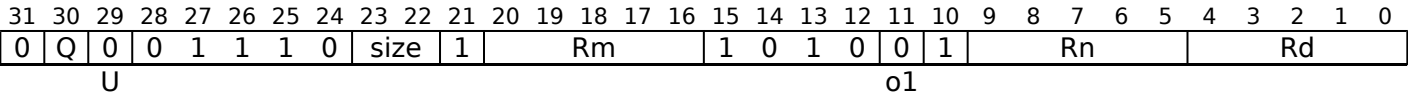
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SMAXP

Signed Maximum Pairwise. This instruction creates a vector by concatenating the vector elements of the first source SIMD&FP register after the vector elements of the second source SIMD&FP register, reads each pair of adjacent vector elements in the two source SIMD&FP registers, writes the largest of each pair of signed integer values into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



SMAXP <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean minimum = (o1 == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(2*datasize) concat = operand2:operand1;
integer element1;
integer element2;
integer maxmin;

for e = 0 to elements-1
    element1 = Int(Elem[concat, 2*e, esize], unsigned);
    element2 = Int(Elem[concat, (2*e)+1, esize], unsigned);
    maxmin = if minimum then Min(element1, element2) else Max(element1, element2);
    Elem[result, e, esize] = maxmin<esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

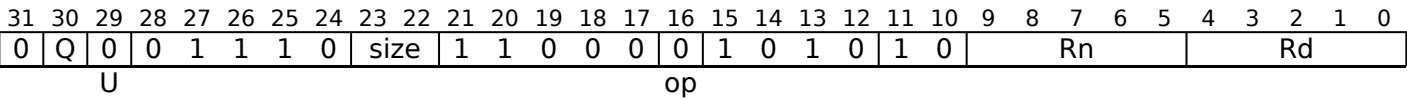
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



SMAV

Signed Maximum across Vector. This instruction compares all the vector elements in the source SIMD&FP register, and writes the largest of the values as a scalar to the destination SIMD&FP register. All the values in this instruction are signed integer values.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



SMAV <V><d>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '100' then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean min = (op == '1');
```

Assembler Symbols

<V> Is the destination width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<T> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	RESERVED
10	1	4S
11	x	RESERVED

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
integer maxmin;
integer element;

maxmin = Int(Elem[operand, 0, esize], unsigned);
for e = 1 to elements-1
    element = Int(Elem[operand, e, esize], unsigned);
    maxmin = if min then Min(maxmin, element) else Max(maxmin, element);

V[d] = maxmin<esize-1:0>;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

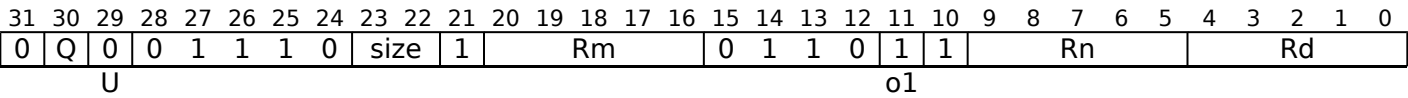
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SMIN

Signed Minimum (vector). This instruction compares corresponding elements in the vectors in the two source SIMD&FP registers, places the smaller of each of the two signed integer values into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



SMIN <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean minimum = (o1 == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
integer maxmin;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    maxmin = if minimum then Min(element1, element2) else Max(element1, element2);
    Elem[result, e, esize] = maxmin<esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

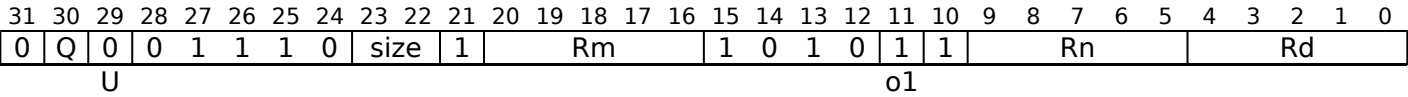
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SMINP

Signed Minimum Pairwise. This instruction creates a vector by concatenating the vector elements of the first source SIMD&FP register after the vector elements of the second source SIMD&FP register, reads each pair of adjacent vector elements in the two source SIMD&FP registers, writes the smallest of each pair of signed integer values into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



SMINP <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean minimum = (o1 == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(2*datasize) concat = operand2:operand1;
integer element1;
integer element2;
integer maxmin;

for e = 0 to elements-1
    element1 = Int(Elem[concat, 2*e, esize], unsigned);
    element2 = Int(Elem[concat, (2*e)+1, esize], unsigned);
    maxmin = if minimum then Min(element1, element2) else Max(element1, element2);
    Elem[result, e, esize] = maxmin<esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

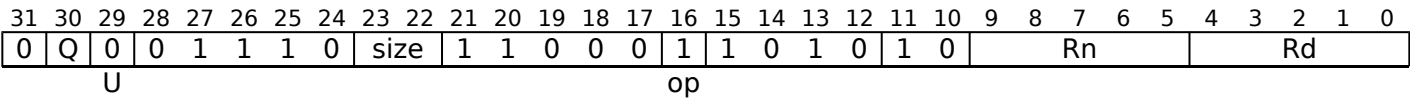
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SMINV

Signed Minimum across Vector. This instruction compares all the vector elements in the source SIMD&FP register, and writes the smallest of the values as a scalar to the destination SIMD&FP register. All the values in this instruction are signed integer values.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



SMINV <V><d>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '100' then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean min = (op == '1');
```

Assembler Symbols

<V> Is the destination width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<T> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	RESERVED
10	1	4S
11	x	RESERVED

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
integer maxmin;
integer element;

maxmin = Int(Elem[operand, 0, esize], unsigned);
for e = 1 to elements-1
    element = Int(Elem[operand, e, esize], unsigned);
    maxmin = if min then Min(maxmin, element) else Max(maxmin, element);

V[d] = maxmin<esize-1:0>;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

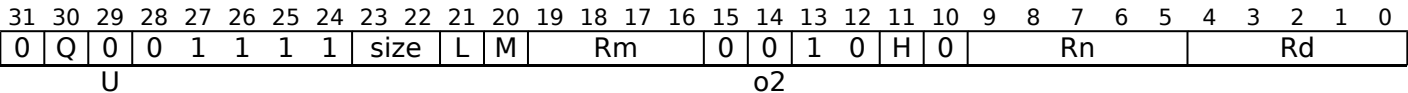


SMLAL, SMLAL2 (by element)

Signed Multiply-Add Long (vector, by element). This instruction multiplies each vector element in the lower or upper half of the first source SIMD&FP register by the specified vector element in the second source SIMD&FP register, and accumulates the results with the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied. All the values in this instruction are signed integer values.

The SMLAL instruction extracts vector elements from the lower half of the first source register, while the SMLAL2 instruction extracts vector elements from the upper half of the first source register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



SMLAL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Ts>[<index>]

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean sub_op = (o2 == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	RESERVED
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in “size:M:Rm”:

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

Restricted to V0-V15 when element size <Ts> is H.

<Ts> Is an element size specifier, encoded in “size”:

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in “size:L:H:M”:

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(idxsizesize) operand2 = V[m];
bits(2*datasize) operand3 = V[d];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;

element2 = Int(Elem[operand2, index, esize], unsigned);
for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    product = (element1*element2)<2*esize-1:0>;
    if sub_op then
        Elem[result, e, 2*esize] = Elem[operand3, e, 2*esize] - product;
    else
        Elem[result, e, 2*esize] = Elem[operand3, e, 2*esize] + product;
V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

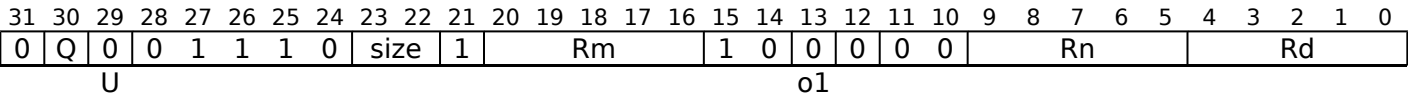


SMLAL, SMLAL2 (vector)

Signed Multiply-Add Long (vector). This instruction multiplies corresponding signed integer values in the lower or upper half of the vectors of the two source SIMD&FP registers, and accumulates the results with the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied.

The SMLAL instruction extracts each source vector from the lower half of each source register, while the SMLAL2 instruction extracts each source vector from the upper half of each source register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



SMLAL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;
boolean sub_op = (o1 == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q 2	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) operand3 = V[d];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;
bits(2*esize) accum;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    product = (element1*element2)<2*esize-1:0>;
    if sub_op then
        accum = Elem[operand3, e, 2*esize] - product;
    else
        accum = Elem[operand3, e, 2*esize] + product;
    Elem[result, e, 2*esize] = accum;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

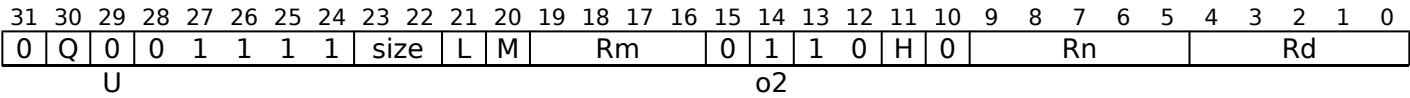
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SMLS, SMLS2 (by element)

Signed Multiply-Subtract Long (vector, by element). This instruction multiplies each vector element in the lower or upper half of the first source SIMD&FP register by the specified vector element of the second source SIMD&FP register and subtracts the results from the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied.

The SMLS instruction extracts vector elements from the lower half of the first source register, while the SMLS2 instruction extracts vector elements from the upper half of the first source register.

Depending on the settings in the CPACR EL1, CPTR EL2, and CPTR EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



SMLS{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Ts>[<index>]

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean sub_op = (o2 == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q 2	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	RESERVED
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in “size:M:Rm”:

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

Restricted to V0-V15 when element size <Ts> is H.

<Ts> Is an element size specifier, encoded in “size”:

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in “size:L:H:M”:

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(idxsizesize) operand2 = V[m];
bits(2*datasize) operand3 = V[d];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;

element2 = Int(Elem[operand2, index, esize], unsigned);
for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    product = (element1*element2)<2*esize-1:0>;
    if sub_op then
        Elem[result, e, 2*esize] = Elem[operand3, e, 2*esize] - product;
    else
        Elem[result, e, 2*esize] = Elem[operand3, e, 2*esize] + product;
V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.



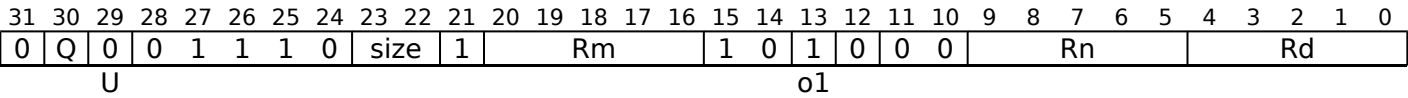


SMLSL, SMLSL2 (vector)

Signed Multiply-Subtract Long (vector). This instruction multiplies corresponding signed integer values in the lower or upper half of the vectors of the two source SIMD&FP registers, and subtracts the results from the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied.

The SMLSL instruction extracts each source vector from the lower half of each source register, while the SMLSL2 instruction extracts each source vector from the upper half of each source register.

Depending on the settings in the CPACR EL1, CPTR EL2, and CPTR EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



SMLSL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;
boolean sub_op = (o1 == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q 2	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) operand3 = V[d];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;
bits(2*esize) accum;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    product = (element1*element2)<2*esize-1:0>;
    if sub_op then
        accum = Elem[operand3, e, 2*esize] - product;
    else
        accum = Elem[operand3, e, 2*esize] + product;
    Elem[result, e, 2*esize] = accum;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

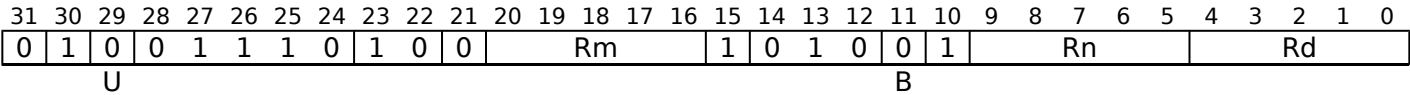
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SMMLA (vector)

Signed 8-bit integer matrix multiply-accumulate. This instruction multiplies the 2x8 matrix of signed 8-bit integer values in the first source vector by the 8x2 matrix of signed 8-bit integer values in the second source vector. The resulting 2x2 32-bit integer matrix product is destructively added to the 32-bit integer matrix accumulator in the destination vector. This is equivalent to performing an 8-way dot product per destination element.

From Armv8.2 to Armv8.5, this is an OPTIONAL instruction. From Armv8.6 it is mandatory for implementations that include Advanced SIMD to support it. [ID\\_AA64ISAR1\\_EL1](#).I8MM indicates whether this instruction is supported.

Vector  
(FEAT\_I8MM)



SMMLA <Vd>.4S, <Vn>.16B, <Vm>.16B

```
if !HaveInt8MatMulExt() then UNDEFINED;
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Rd);
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP third source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

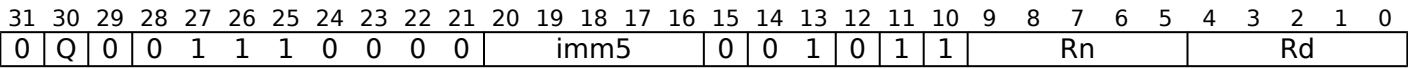
```
CheckFPAdvSIMDEnabled64();
bits(128) operand1 = V[n];
bits(128) operand2 = V[m];
bits(128) addend = V[d];

V[d] = MatMulAdd(addend, operand1, operand2, FALSE, FALSE);
```

SMOV

Signed Move vector element to general-purpose register. This instruction reads the signed integer from the source SIMD&FP register, sign-extends it to form a 32-bit or 64-bit value, and writes the result to destination general-purpose register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



32-bit (Q == 0)

```
SMOV <Wd>, <Vn>.<Ts>[<index>]
```

64-reg,SMOV-64-reg (Q == 1)

```
SMOV <Xd>, <Vn>.<Ts>[<index>]
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer size;
case Q:imm5 of
    when 'xxxxx1' size = 0;    // SMOV [WX]d, Vn.B
    when 'xxxx10' size = 1;    // SMOV [WX]d, Vn.H
    when '1xx100' size = 2;    // SMOV Xd, Vn.S
    otherwise UNDEFINED;

integer idxdsize = if imm5<4> == '1' then 128 else 64;
integer index = UInt(imm5<4:size+1>);
integer esize = 8 << size;
integer datasize = if Q == '1' then 64 else 32;
```

Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.
- <Ts> For the 32-bit variant: is an element size specifier, encoded in "imm5":

imm5	<Ts>
xxx00	RESERVED
xxxx1	B
xxx10	H

For the 64-reg,SMOV-64-reg variant: is an element size specifier, encoded in "imm5":

imm5	<Ts>
xx000	RESERVED
xxxx1	B
xxx10	H
xx100	S

- <index> For the 32-bit variant: is the element index encoded in "imm5":

imm5	<index>
xxx00	RESERVED
xxxx1	imm5<4:1>
xxx10	imm5<4:2>

For the 64-reg,SMOV-64-reg variant: is the element index encoded in “imm5”:

imm5	<index>
xx000	RESERVED
xxxx1	imm5<4:1>
xxx10	imm5<4:2>
xx100	imm5<4:3>

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(idxdsize) operand = V[n];
X[d] = SignExtend(Elem[operand, index, esize], datasize);
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

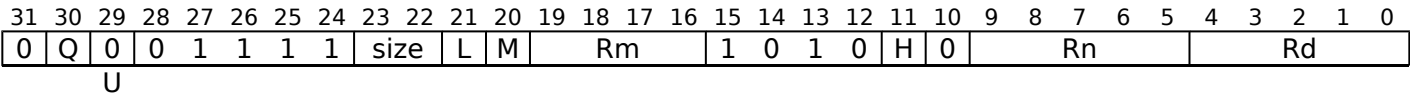
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SMULL, SMULL2 (by element)

Signed Multiply Long (vector, by element). This instruction multiplies each vector element in the lower or upper half of the first source SIMD&FP register by the specified vector element of the second source SIMD&FP register, places the result in a vector, and writes the vector to the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied.

The SMULL instruction extracts vector elements from the lower half of the first source register, while the SMULL2 instruction extracts vector elements from the upper half of the first source register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



SMULL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Ts>[<index>]

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	RESERVED
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in “size:M:Rm”:

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

Restricted to V0-V15 when element size <Ts> is H.

<Ts> Is an element size specifier, encoded in “size”:

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in “size:L:H:M”:

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(idxsdsie) operand2 = V[m];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;

element2 = Int(Elem[operand2, index, esize], unsigned);
for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    product = (element1*element2)<2*esize-1:0>;
    Elem[result, e, 2*esize] = product;

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

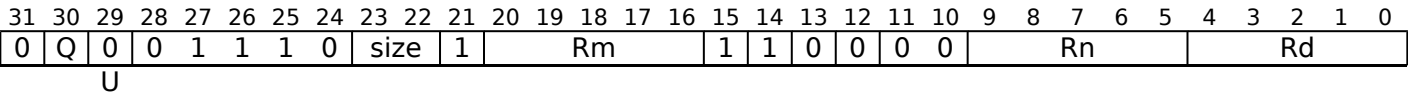
SMULL, SMULL2 (vector)

Signed Multiply Long (vector). This instruction multiplies corresponding signed integer values in the lower or upper half of the vectors of the two source SIMD&FP registers, places the results in a vector, and writes the vector to the destination SIMD&FP register.

The destination vector elements are twice as long as the elements that are multiplied.

The SMULL instruction extracts each source vector from the lower half of each source register, while the SMULL2 instruction extracts each source vector from the upper half of each source register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



SMULL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q 2	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.



## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
integer element1;
integer element2;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    Elem[result, e, 2*esize] = (element1*element2)<2*esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SQABS

Signed saturating Absolute value. This instruction reads each vector element from the source SIMD&FP register, puts the absolute value of the result into a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are signed integer values.

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit *FPSR.QC* is set.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	size	1	0	0	0	0	0	0	0	1	1	1	1	0	Rn				Rd					
U																															

SQABS <V><d>, <V><n>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean neg = (U == '1');
```

Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	size	1	0	0	0	0	0	0	0	1	1	1	1	0	Rn				Rd					
U																															

SQABS <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean neg = (U == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D

- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
integer element;
boolean sat;

for e = 0 to elements-1
    element = SInt(Elem[operand, e, esize]);
    if neg then
        element = -element;
    else
        element = Abs(element);
    (Elem[result, e, esize], sat) = SignedSatQ(element, esize);
    if sat then FPSR.QC = '1';

V[d] = result;
```

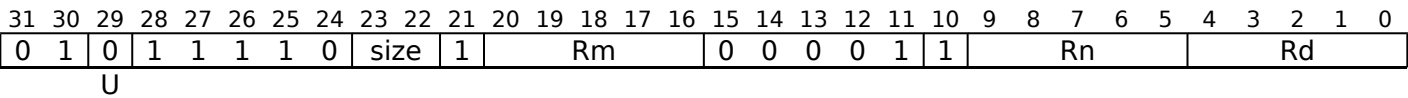
SQADD

Signed saturating Add. This instruction adds the values of corresponding elements of the two source SIMD&FP registers, places the results into a vector, and writes the vector to the destination SIMD&FP register. If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit *FPSR.QC* is set.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

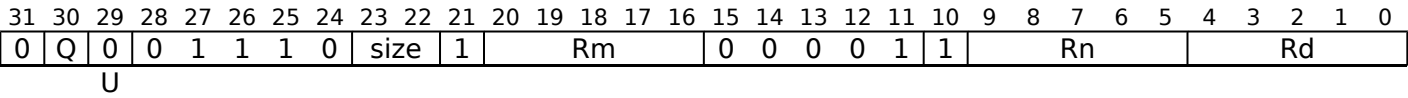
Scalar



SQADD <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
```

Vector



SQADD <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
integer sum;
boolean sat;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    sum = element1 + element2;
    (Elem[result, e, esize], sat) = SatQ(sum, esize, unsigned);
    if sat then FPSR.QC = '1';

V[d] = result;
```

## SQDMLAL, SQDMLAL2 (by element)

Signed saturating Doubling Multiply-Add Long (by element). This instruction multiplies each vector element in the lower or upper half of the first source SIMD&FP register by the specified vector element of the second source SIMD&FP register, doubles the results, and accumulates the final results with the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied. If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

The SQDMLAL instruction extracts vector elements from the lower half of the first source register, while the SQDMLAL2 instruction extracts vector elements from the upper half of the first source register. Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	size	L	M			Rm		0	0	1	1	H	0									Rd		
																	o2														

SQDMLAL <Va><d>, <Vb><n>, <Vm>.<Ts>[<index>]

```
integer idxsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
  when '01' index = UInt(H:L:M); Rmhi = '0';
  when '10' index = UInt(H:L); Rmhi = M;
  otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
integer part = 0;

boolean sub_op = (o2 == '1');
```

### Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	size	L	M			Rm		0	0	1	1	H	0									Rd		
																	o2														

SQDMLAL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Ts>[<index>]

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean sub_op = (o2 == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	RESERVED
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Va> Is the destination width specifier, encoded in “size”:

size	<Va>
00	RESERVED
01	S
10	D
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vb> Is the source width specifier, encoded in “size”:

size	<Vb>
00	RESERVED
01	H
10	S
11	RESERVED

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in "size:M:Rm":

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

Restricted to V0-V15 when element size <Ts> is H.

<Ts> Is an element size specifier, encoded in "size":

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in "size:L:H:M":

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(idxdsize) operand2 = V[m];
bits(2*datasize) operand3 = V[d];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;
integer accum;
boolean sat1;
boolean sat2;

element2 = SInt(Elem[operand2, index, esize]);
for e = 0 to elements-1
    element1 = SInt(Elem[operand1, e, esize]);
    (product, sat1) = SignedSatQ(2 * element1 * element2, 2 * esize);
    if sub_op then
        accum = SInt(Elem[operand3, e, 2*esize]) - SInt(product);
    else
        accum = SInt(Elem[operand3, e, 2*esize]) + SInt(product);
    (Elem[result, e, 2*esize], sat2) = SignedSatQ(accum, 2 * esize);
    if sat1 || sat2 then FPSR.QC = '1';

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# SQDMLAL, SQDMLAL2 (vector)

Signed saturating Doubling Multiply-Add Long. This instruction multiplies corresponding signed integer values in the lower or upper half of the vectors of the two source SIMD&FP registers, doubles the results, and accumulates the final results with the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied.

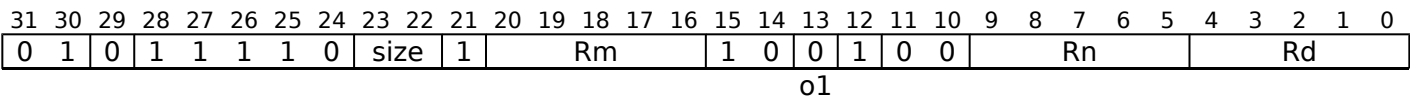
If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

The SQDMLAL instruction extracts each source vector from the lower half of each source register, while the SQDMLAL2 instruction extracts each source vector from the upper half of each source register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar



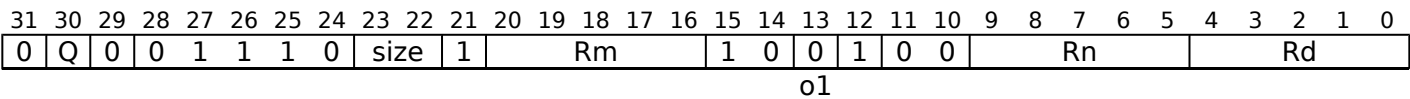
**SQDMLAL** <Va><d>, <Vb><n>, <Vb><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '00' || size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
integer part = 0;

boolean sub_op = (o1 == '1');
```

## Vector



**SQDMLAL{2}** <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '00' || size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean sub_op = (o1 == '1');
```

## Assembler Symbols

- 2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in "size":

size	<Ta>
00	RESERVED
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in "size:Q":

size	Q	<Tb>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

<Va> Is the destination width specifier, encoded in "size":

size	<Va>
00	RESERVED
01	S
10	D
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vb> Is the source width specifier, encoded in "size":

size	<Vb>
00	RESERVED
01	H
10	S
11	RESERVED

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) operand3 = V[d];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;
integer accum;
boolean sat1;
boolean sat2;

for e = 0 to elements-1
    element1 = SInt(Elem[operand1, e, esize]);
    element2 = SInt(Elem[operand2, e, esize]);
    (product, sat1) = SignedSatQ(2 * element1 * element2, 2 * esize);
    if sub_op then
        accum = SInt(Elem[operand3, e, 2*esize]) - SInt(product);
    else
        accum = SInt(Elem[operand3, e, 2*esize]) + SInt(product);
    (Elem[result, e, 2*esize], sat2) = SignedSatQ(accum, 2 * esize);
    if sat1 || sat2 then FPSR.QC = '1';

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## SQDMLSL, SQDMLSL2 (by element)

Signed saturating Doubling Multiply-Subtract Long (by element). This instruction multiplies each vector element in the lower or upper half of the first source SIMD&FP register by the specified vector element of the second source SIMD&FP register, doubles the results, and subtracts the final results from the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied. All the values in this instruction are signed integer values.

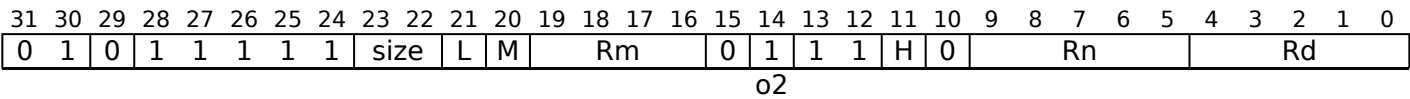
If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit *FPSR.QC* is set.

The SQDMLSL instruction extracts vector elements from the lower half of the first source register, while the SQDMLSL2 instruction extracts vector elements from the upper half of the first source register.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar



SQDMLSL <Va><d>, <Vb><n>, <Vm>.<Ts>[<index>]

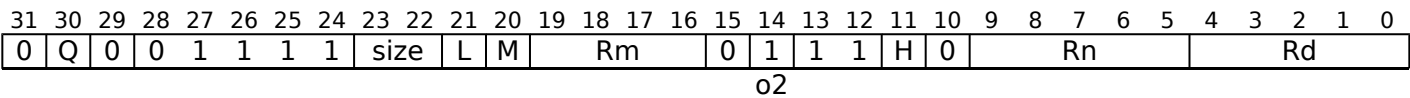
```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
integer part = 0;

boolean sub_op = (o2 == '1');
```

### Vector



SQDMLSL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Ts>[<index>]

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean sub_op = (o2 == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	RESERVED
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Va> Is the destination width specifier, encoded in “size”:

size	<Va>
00	RESERVED
01	S
10	D
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vb> Is the source width specifier, encoded in “size”:

size	<Vb>
00	RESERVED
01	H
10	S
11	RESERVED

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in "size:M:Rm":

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

Restricted to V0-V15 when element size <Ts> is H.

<Ts> Is an element size specifier, encoded in "size":

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in "size:L:H:M":

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(idxdsize) operand2 = V[m];
bits(2*datasize) operand3 = V[d];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;
integer accum;
boolean sat1;
boolean sat2;

element2 = SInt(Elem[operand2, index, esize]);
for e = 0 to elements-1
    element1 = SInt(Elem[operand1, e, esize]);
    (product, sat1) = SignedSatQ(2 * element1 * element2, 2 * esize);
    if sub_op then
        accum = SInt(Elem[operand3, e, 2*esize]) - SInt(product);
    else
        accum = SInt(Elem[operand3, e, 2*esize]) + SInt(product);
    (Elem[result, e, 2*esize], sat2) = SignedSatQ(accum, 2 * esize);
    if sat1 || sat2 then FPSR.QC = '1';

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SQDMLSL, SQDMLSL2 (vector)

Signed saturating Doubling Multiply-Subtract Long. This instruction multiplies corresponding signed integer values in the lower or upper half of the vectors of the two source SIMD&FP registers, doubles the results, and subtracts the final results from the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied.

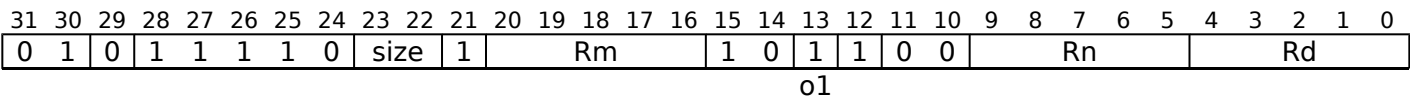
If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

The SQDMLSL instruction extracts each source vector from the lower half of each source register, while the SQDMLSL2 instruction extracts each source vector from the upper half of each source register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar



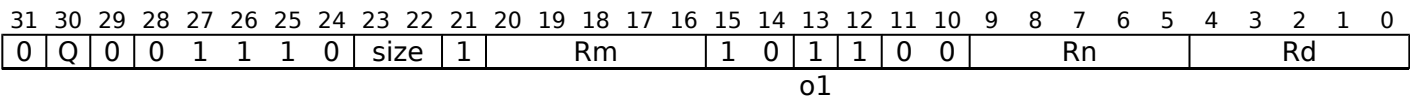
SQDMLSL <Va><d>, <Vb><n>, <Vb><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '00' || size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
integer part = 0;

boolean sub_op = (o1 == '1');
```

## Vector



SQDMLSL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '00' || size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean sub_op = (o1 == '1');
```

## Assembler Symbols

- 2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in "size":

size	<Ta>
00	RESERVED
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in "size:Q":

size	Q	<Tb>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

<Va> Is the destination width specifier, encoded in "size":

size	<Va>
00	RESERVED
01	S
10	D
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vb> Is the source width specifier, encoded in "size":

size	<Vb>
00	RESERVED
01	H
10	S
11	RESERVED

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.



## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) operand3 = V[d];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;
integer accum;
boolean sat1;
boolean sat2;

for e = 0 to elements-1
    element1 = SInt(Elem[operand1, e, esize]);
    element2 = SInt(Elem[operand2, e, esize]);
    (product, sat1) = SignedSatQ(2 * element1 * element2, 2 * esize);
    if sub_op then
        accum = SInt(Elem[operand3, e, 2*esize]) - SInt(product);
    else
        accum = SInt(Elem[operand3, e, 2*esize]) + SInt(product);
    (Elem[result, e, 2*esize], sat2) = SignedSatQ(accum, 2 * esize);
    if sat1 || sat2 then FPSR.QC = '1';

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## SQDMULH (by element)

Signed saturating Doubling Multiply returning High half (by element). This instruction multiplies each vector element in the first source SIMD&FP register by the specified vector element of the second source SIMD&FP register, doubles the results, places the most significant half of the final results into a vector, and writes the vector to the destination SIMD&FP register.

The results are truncated. For rounded results, see [SQRDMULH](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	size	L	M				Rm		1	1	0	0	H	0					Rn				Rd	
op																															

SQDMULH [<V><d>](#), [<V><n>](#), [<Vm>.<Ts>](#)[[<index>](#)]

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
  when '01' index = UInt(H:L:M); Rmhi = '0';
  when '10' index = UInt(H:L); Rmhi = M;
  otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;

boolean round = (op == '1');
```

### Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	size	L	M	Rm				1	1	0	0	H	0	Rn				Rd						
op																															

SQDMULH [<Vd>.<T>](#), [<Vn>.<T>](#), [<Vm>.<Ts>](#)[[<index>](#)]

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
  when '01' index = UInt(H:L:M); Rmhi = '0';
  when '10' index = UInt(H:L); Rmhi = M;
  otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean round = (op == '1');
```

## Assembler Symbols

<V> Is a width specifier, encoded in "size":

size	<V>
00	RESERVED
01	H
10	S
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in "size:M:Rm":

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

Restricted to V0-V15 when element size <Ts> is H.

<Ts> Is an element size specifier, encoded in "size":

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in "size:L:H:M":

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(idxdsize) operand2 = V[m];
bits(datasize) result;
integer round_const = if round then 1 << (esize - 1) else 0;
integer element1;
integer element2;
integer product;
boolean sat;

element2 = SInt(Elem[operand2, index, esize]);
for e = 0 to elements-1
    element1 = SInt(Elem[operand1, e, esize]);
    product = (2 * element1 * element2) + round_const;
    // The following only saturates if element1 and element2 equal -(2^(esize-1))
    (Elem[result, e, esize], sat) = SignedSatQ(product >> esize, esize);
    if sat then FPSR.QC = '1';

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SQDMULH (vector)

Signed saturating Doubling Multiply returning High half. This instruction multiplies the values of corresponding elements of the two source SIMD&FP registers, doubles the results, places the most significant half of the final results into a vector, and writes the vector to the destination SIMD&FP register.

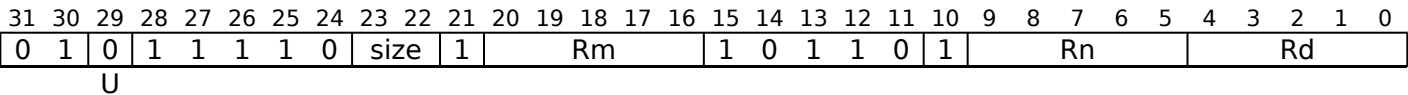
The results are truncated. For rounded results, see [SQRDMULH](#).

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

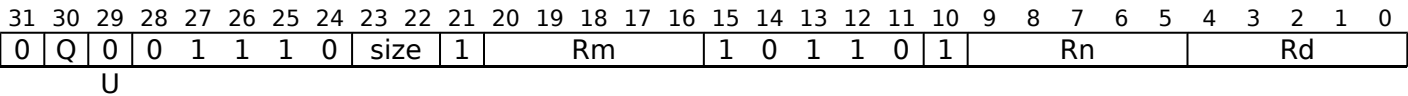
Scalar



SQDMULH <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' || size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean rounding = (U == '1');
```

Vector



SQDMULH <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' || size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean rounding = (U == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	RESERVED
01	H
10	S
11	RESERVED

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer round_const = if rounding then 1 << (esize - 1) else 0;
integer element1;
integer element2;
integer product;
boolean sat;

for e = 0 to elements-1
    element1 = SInt(Elem[operand1, e, esize]);
    element2 = SInt(Elem[operand2, e, esize]);
    product = (2 * element1 * element2) + round_const;
    (Elem[result, e, esize], sat) = SignedSatQ(product >> esize, esize);
    if sat then FPSR.QC = '1';

V[d] = result;
```

## SQDMULL, SQDMULL2 (by element)

Signed saturating Doubling Multiply Long (by element). This instruction multiplies each vector element in the lower or upper half of the first source SIMD&FP register by the specified vector element of the second source SIMD&FP register, doubles the results, places the final results in a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are signed integer values.

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

The SQDMULL instruction extracts the first source vector from the lower half of the first source register, while the SQDMULL2 instruction extracts the first source vector from the upper half of the first source register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	size	L	M			Rm			1	0	1	1	H	0				Rn				Rd		

**SQDMULL** <Va><d>, <Vb><n>, <Vm>.<Ts>[<index>]

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
  when '01' index = UInt(H:L:M); Rmhi = '0';
  when '10' index = UInt(H:L); Rmhi = M;
  otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
integer part = 0;
```

### Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	size	L	M			Rm			1	0	1	1	H	0				Rn				Rd		

**SQDMULL{2}** <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Ts>[<index>]

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
  when '01' index = UInt(H:L:M); Rmhi = '0';
  when '10' index = UInt(H:L); Rmhi = M;
  otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;
```

## Assembler Symbols

- 2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in "Q":

Q	2
0	[absent]
1	[present]

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

- <Ta> Is an arrangement specifier, encoded in "size":

size	<Ta>
00	RESERVED
01	4S
10	2D
11	RESERVED

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

- <Tb> Is an arrangement specifier, encoded in "size:Q":

size	Q	<Tb>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Va> Is the destination width specifier, encoded in "size":

size	<Va>
00	RESERVED
01	S
10	D
11	RESERVED

- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

- <Vb> Is the source width specifier, encoded in "size":

size	<Vb>
00	RESERVED
01	H
10	S
11	RESERVED

- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

- <Vm> Is the name of the second SIMD&FP source register, encoded in "size:M:Rm":

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

Restricted to V0-V15 when element size <Ts> is H.

- <Ts> Is an element size specifier, encoded in "size":



size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in “size:L:H:M”:

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();

bits(datasize) operand1 = Vpart[n, part];
bits(idxdsize) operand2 = V[m];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;
boolean sat;

element2 = SInt(Elem[operand2, index, esize]);
for e = 0 to elements-1
    element1 = SInt(Elem[operand1, e, esize]);
    (product, sat) = SignedSatQ(2 * element1 * element2, 2 * esize);
    Elem[result, e, 2*esize] = product;
    if sat then FPSR.QC = '1';

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SQDMULL, SQDMULL2 (vector)

Signed saturating Doubling Multiply Long. This instruction multiplies corresponding vector elements in the lower or upper half of the two source SIMD&FP registers, doubles the results, places the final results in a vector, and writes the vector to the destination SIMD&FP register.

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit *FPSR.QC* is set.

The SQDMULL instruction extracts each source vector from the lower half of each source register, while the SQDMULL2 instruction extracts each source vector from the upper half of each source register.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	size	1				Rm			1	1	0	1	0	0				Rn				Rd		

SQDMULL <Va><d>, <Vb><n>, <Vb><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '00' || size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
integer part = 0;
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	size	1				Rm			1	1	0	1	0	0				Rn				Rd		

SQDMULL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '00' || size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;
```

## Assembler Symbols

- 2

Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the “Rd” field.
- <Ta>

Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	RESERVED
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in "size:Q":

size	Q	<Tb>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

<Va> Is the destination width specifier, encoded in "size":

size	<Va>
00	RESERVED
01	S
10	D
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vb> Is the source width specifier, encoded in "size":

size	<Vb>
00	RESERVED
01	H
10	S
11	RESERVED

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;
boolean sat;

for e = 0 to elements-1
    element1 = SInt(Elem[operand1, e, esize]);
    element2 = SInt(Elem[operand2, e, esize]);
    (product, sat) = SignedSatQ(2 * element1 * element2, 2 * esize);
    Elem[result, e, 2*esize] = product;
    if sat then FPSR.QC = '1';

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SQNEG

Signed saturating Negate. This instruction reads each vector element from the source SIMD&FP register, negates each value, places the result into a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are signed integer values.

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit *FPSR.QC* is set.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	size	1	0	0	0	0	0	0	0	1	1	1	1	0	Rn				Rd					
U																															

SQNEG <V><d>, <V><n>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean neg = (U == '1');
```

Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	size	1	0	0	0	0	0	0	0	1	1	1	1	0	Rn				Rd					
U																															

SQNEG <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean neg = (U == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
integer element;
boolean sat;

for e = 0 to elements-1
    element = SInt(Elem[operand, e, esize]);
    if neg then
        element = -element;
    else
        element = Abs(element);
    (Elem[result, e, esize], sat) = SignedSatQ(element, esize);
    if sat then FPSR.QC = '1';

V[d] = result;
```

## SQRDMLAH (by element)

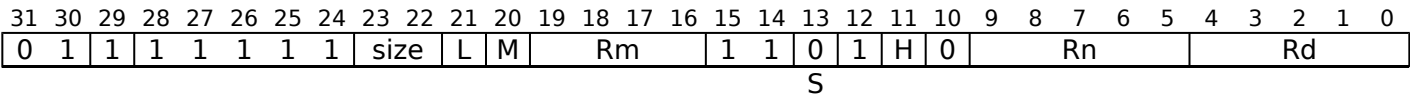
Signed Saturating Rounding Doubling Multiply Accumulate returning High Half (by element). This instruction multiplies the vector elements of the first source SIMD&FP register with the value of a vector element of the second source SIMD&FP register without saturating the multiply results, doubles the results, and accumulates the most significant half of the final results with the vector elements of the destination SIMD&FP register. The results are rounded.

If any of the results overflow, they are saturated. The cumulative saturation bit, [FPSR.QC](#), is set if saturation occurs.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar (FEAT\_RDM)



SQRDMLAH <V><d>, <V><n>, <Vm>.<Ts>[<index>]

```
if !HaveQRDMLAHExt() then UNDEFINED;

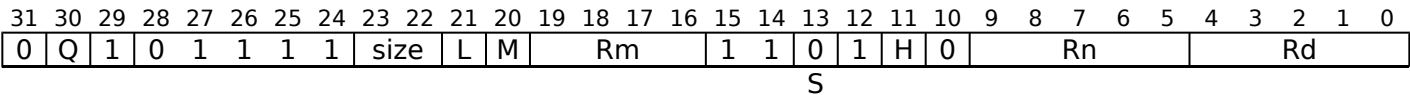
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;

boolean rounding = TRUE;
boolean sub_op = (S == '1');
```

### Vector (FEAT\_RDM)



SQRDMLAH <Vd>.<T>, <Vn>.<T>, <Vm>.<Ts>[<index>]

```
if !HaveQRDMLAHExt() then UNDEFINED;

integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean rounding = TRUE;
boolean sub_op = (S == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	RESERVED
01	H
10	S
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in “size:M:Rm”:

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

Restricted to V0-V15 when element size <Ts> is H.

<Ts> Is an element size specifier, encoded in “size”:

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in “size:L:H:M”:

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(idxdsize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
integer rounding_const = if rounding then 1 << (esize - 1) else 0;
integer element1;
integer element2;
integer element3;
integer product;
boolean sat;

element2 = SInt(Elem[operand2, index, esize]);
for e = 0 to elements-1
    element1 = SInt(Elem[operand1, e, esize]);
    element3 = SInt(Elem[operand3, e, esize]);
    if sub_op then
        accum = ((element3 << esize) - 2 * (element1 * element2) + rounding_const);
    else
        accum = ((element3 << esize) + 2 * (element1 * element2) + rounding_const);
    (Elem[result, e, esize], sat) = SignedSatQ(accum >> esize, esize);
    if sat then FPSR.QC = '1';

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# SQRDMLAH (vector)

Signed Saturating Rounding Doubling Multiply Accumulate returning High Half (vector). This instruction multiplies the vector elements of the first source SIMD&FP register with the corresponding vector elements of the second source SIMD&FP register without saturating the multiply results, doubles the results, and accumulates the most significant half of the final results with the vector elements of the destination SIMD&FP register. The results are rounded. If any of the results overflow, they are saturated. The cumulative saturation bit, [FPSR.QC](#), is set if saturation occurs. Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar (FEAT\_RDM)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	size	0	Rm				1	0	0	0	0	1	Rn				Rd							
																					S										

SQRDMLAH <V><d>, <V><n>, <V><m>

```
if !HaveQRDMLAHExt() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' || size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean rounding = TRUE;
boolean sub_op = (S == '1');
```

## Vector (FEAT\_RDM)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	size	0	Rm					1	0	0	0	0	1	Rn					Rd					
																					S										

SQRDMLAH <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveQRDMLAHExt() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' || size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean rounding = TRUE;
boolean sub_op = (S == '1');
```

## Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	RESERVED
01	H
10	S
11	RESERVED

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
integer rounding_const = if rounding then 1 << (esize - 1) else 0;
integer element1;
integer element2;
integer element3;
integer product;
boolean sat;

for e = 0 to elements-1
    element1 = SInt(Elem[operand1, e, esize]);
    element2 = SInt(Elem[operand2, e, esize]);
    element3 = SInt(Elem[operand3, e, esize]);
    if sub_op then
        accum = ((element3 << esize) - 2 * (element1 * element2) + rounding_const);
    else
        accum = ((element3 << esize) + 2 * (element1 * element2) + rounding_const);
    (Elem[result, e, esize], sat) = SignedSatQ(accum >> esize, esize);
    if sat then FPSR.QC = '1';

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

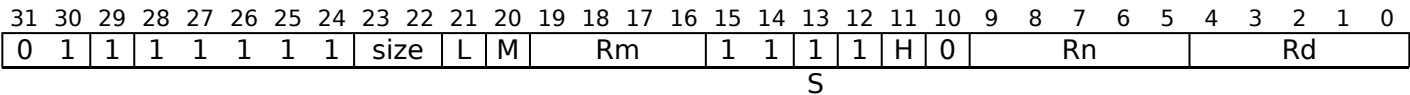
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## SQRDMLSH (by element)

Signed Saturating Rounding Doubling Multiply Subtract returning High Half (by element). This instruction multiplies the vector elements of the first source SIMD&FP register with the value of a vector element of the second source SIMD&FP register without saturating the multiply results, doubles the results, and subtracts the most significant half of the final results from the vector elements of the destination SIMD&FP register. The results are rounded. If any of the results overflow, they are saturated. The cumulative saturation bit, [FPSR.QC](#), is set if saturation occurs. Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar (FEAT\_RDM)



SQRDMLSH <V><d>, <V><n>, <Vm>.<Ts>[<index>]

```
if !HaveQRDMLAHExt() then UNDEFINED;

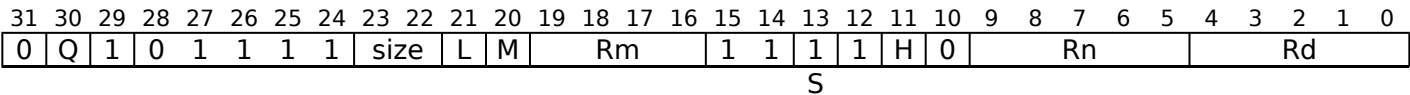
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;

boolean rounding = TRUE;
boolean sub_op = (S == '1');
```

### Vector (FEAT\_RDM)



SQRDMLSH <Vd>.<T>, <Vn>.<T>, <Vm>.<Ts>[<index>]

```

if !HaveQRDMLAHExt() then UNDEFINED;

integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean rounding = TRUE;
boolean sub_op = (S == '1');

```

## Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	RESERVED
01	H
10	S
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the “Rd” field.

<n> Is the number of the first SIMD&FP source register, encoded in the “Rn” field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the “Rd” field.

<T> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the “Rn” field.

<Vm> Is the name of the second SIMD&FP source register, encoded in “size:M:Rm”:

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

Restricted to V0-V15 when element size <Ts> is H.

<Ts> Is an element size specifier, encoded in “size”:

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in “size:L:H:M”:

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(idxdsize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
integer rounding_const = if rounding then 1 << (esize - 1) else 0;
integer element1;
integer element2;
integer element3;
integer product;
boolean sat;

element2 = SInt(Elem[operand2, index, esize]);
for e = 0 to elements-1
    element1 = SInt(Elem[operand1, e, esize]);
    element3 = SInt(Elem[operand3, e, esize]);
    if sub_op then
        accum = ((element3 << esize) - 2 * (element1 * element2) + rounding_const);
    else
        accum = ((element3 << esize) + 2 * (element1 * element2) + rounding_const);
    (Elem[result, e, esize], sat) = SignedSatQ(accum >> esize, esize);
    if sat then FPSR.QC = '1';

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SQRDMLSH (vector)

Signed Saturating Rounding Doubling Multiply Subtract returning High Half (vector). This instruction multiplies the vector elements of the first source SIMD&FP register with the corresponding vector elements of the second source SIMD&FP register without saturating the multiply results, doubles the results, and subtracts the most significant half of the final results from the vector elements of the destination SIMD&FP register. The results are rounded. If any of the results overflow, they are saturated. The cumulative saturation bit, [FPSR.QC](#), is set if saturation occurs. Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar (FEAT\_RDM)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	size	0	Rm				1	0	0	0	1	1	Rn				Rd							
S																															

SQRDMLSH <V><d>, <V><n>, <V><m>

```
if !HaveQRDMLAExt() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' || size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean rounding = TRUE;
boolean sub_op = (S == '1');
```

## Vector (FEAT\_RDM)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	size	0	Rm				1	0	0	0	1	1	Rn				Rd							
S																															

SQRDMLSH <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveQRDMLAExt() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' || size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean rounding = TRUE;
boolean sub_op = (S == '1');
```

## Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	RESERVED
01	H
10	S
11	RESERVED

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
integer rounding_const = if rounding then 1 << (esize - 1) else 0;
integer element1;
integer element2;
integer element3;
integer product;
boolean sat;

for e = 0 to elements-1
    element1 = SInt(Elem[operand1, e, esize]);
    element2 = SInt(Elem[operand2, e, esize]);
    element3 = SInt(Elem[operand3, e, esize]);
    if sub_op then
        accum = ((element3 << esize) - 2 * (element1 * element2) + rounding_const);
    else
        accum = ((element3 << esize) + 2 * (element1 * element2) + rounding_const);
    (Elem[result, e, esize], sat) = SignedSatQ(accum >> esize, esize);
    if sat then FPSR.QC = '1';

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## SQRDMULH (by element)

Signed saturating Rounding Doubling Multiply returning High half (by element). This instruction multiplies each vector element in the first source SIMD&FP register by the specified vector element of the second source SIMD&FP register, doubles the results, places the most significant half of the final results into a vector, and writes the vector to the destination SIMD&FP register.

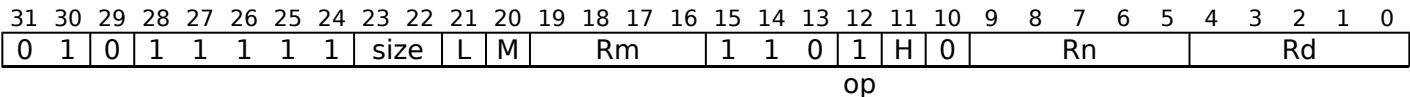
The results are rounded. For truncated results, see [SQDMULH](#).

If any of the results overflows, they are saturated. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar



SQRDMULH [<V><d>](#), [<V><n>](#), [<Vm>.<Ts>](#)[[<index>](#)]

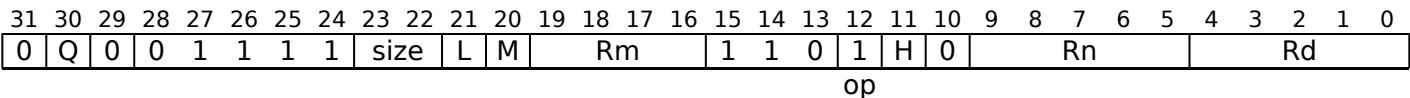
```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;

boolean round = (op == '1');
```

### Vector





SQRDMULH <Vd>.<T>, <Vn>.<T>, <Vm>.<Ts>[<index>]

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
  when '01' index = UInt(H:L:M); Rmhi = '0';
  when '10' index = UInt(H:L); Rmhi = M;
  otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean round = (op == '1');
```

## Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	RESERVED
01	H
10	S
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in “size:M:Rm”:

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

Restricted to V0-V15 when element size <Ts> is H.

<Ts> Is an element size specifier, encoded in “size”:

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in “size:L:H:M”:

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(idxdsize) operand2 = V[m];
bits(datasize) result;
integer round_const = if round then 1 << (esize - 1) else 0;
integer element1;
integer element2;
integer product;
boolean sat;

element2 = SInt(Elem[operand2, index, esize]);
for e = 0 to elements-1
    element1 = SInt(Elem[operand1, e, esize]);
    product = (2 * element1 * element2) + round_const;
    // The following only saturates if element1 and element2 equal -(2^(esize-1))
    (Elem[result, e, esize], sat) = SignedSatQ(product >> esize, esize);
    if sat then FPSR.QC = '1';

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SQRDMULH (vector)

Signed saturating Rounding Doubling Multiply returning High half. This instruction multiplies the values of corresponding elements of the two source SIMD&FP registers, doubles the results, places the most significant half of the final results into a vector, and writes the vector to the destination SIMD&FP register.

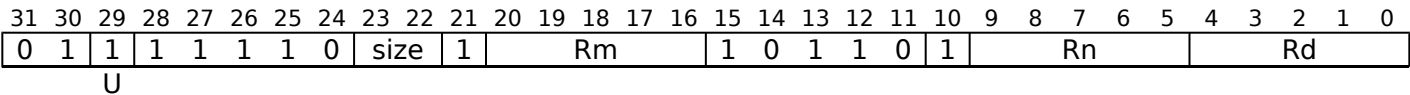
The results are rounded. For truncated results, see [SQDMULH](#).

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

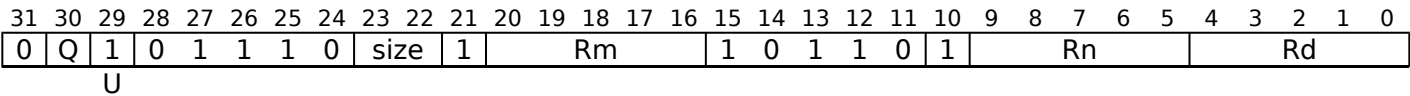
Scalar



SQRDMULH <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' || size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean rounding = (U == '1');
```

Vector



SQRDMULH <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' || size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean rounding = (U == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	RESERVED
01	H
10	S
11	RESERVED

<d> Is the number of the SIMD&FP destination register, in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer round_const = if rounding then 1 << (esize - 1) else 0;
integer element1;
integer element2;
integer product;
boolean sat;

for e = 0 to elements-1
    element1 = SInt(Elem[operand1, e, esize]);
    element2 = SInt(Elem[operand2, e, esize]);
    product = (2 * element1 * element2) + round_const;
    (Elem[result, e, esize], sat) = SignedSatQ(product >> esize, esize);
    if sat then FPSR.QC = '1';

V[d] = result;
```

# SQRSHL

Signed saturating Rounding Shift Left (register). This instruction takes each vector element in the first source SIMD&FP register, shifts it by a value from the least significant byte of the corresponding vector element of the second source SIMD&FP register, places the results into a vector, and writes the vector to the destination SIMD&FP register.

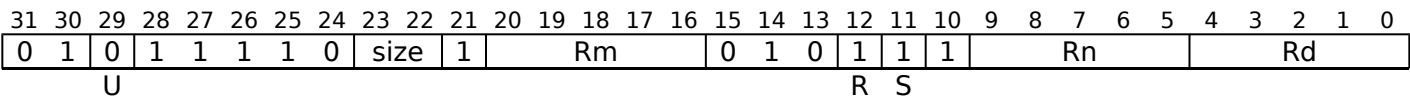
If the shift value is positive, the operation is a left shift. Otherwise, it is a right shift. The results are rounded. For truncated results, see [SQSHL](#).

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

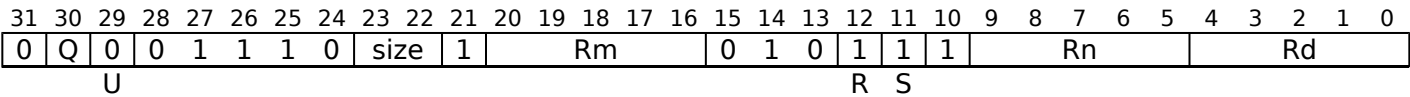
## Scalar



SQRSHL <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
if S == '0' && size != '11' then UNDEFINED;
```

## Vector



SQRSHL <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
```

## Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

integer round_const = 0;
integer shift;
integer element;
boolean sat;

for e = 0 to elements-1
    shift = SInt(Elem[operand2, e, esize]<7:0>);
    if rounding then
        round_const = 1 << (-shift - 1);    // 0 for left shift, 2^(n-1) for right shift
    element = (Int(Elem[operand1, e, esize], unsigned) + round_const) << shift;
    if saturating then
        (Elem[result, e, esize], sat) = SatQ(element, esize, unsigned);
        if sat then FPSR.QC = '1';
    else
        Elem[result, e, esize] = element<esize-1:0>;

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## SQRSHRN, SQRSHRN2

Signed saturating Rounded Shift Right Narrow (immediate). This instruction reads each vector element in the source SIMD&FP register, right shifts each result by an immediate value, saturates each shifted result to a value that is half the original width, puts the final result into a vector, and writes the vector to the lower or upper half of the destination SIMD&FP register. All the values in this instruction are signed integer values. The destination vector elements are half as long as the source vector elements. The results are rounded. For truncated results, see [SQSHRN](#).

The SQRSHRN instruction writes the vector to the lower half of the destination register and clears the upper half, while the SQRSHRN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.

If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	0	!= 0000				immb			1	0	0	1	1	1	Rn				Rd					
U									immh				op																		

**SQRSHRN** <Vb><d>, <Va><n>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then UNDEFINED;
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = esize;
integer elements = 1;
integer part = 0;

integer shift = (2 * esize) - UInt(immh:immb);
boolean round = (op == '1');
boolean unsigned = (U == '1');
```

### Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	0	!= 0000				immb			1	0	0	1	1	1	Rn				Rd					
U									immh				op																		

**SQRSHRN{2}** <Vd>.<Tb>, <Vn>.<Ta>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

integer shift = (2 * esize) - UInt(immh:immb);
boolean round = (op == '1');
boolean unsigned = (U == '1');
```

## Assembler Symbols

- 2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in "Q":

Q	2
0	[absent]
1	[present]

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

- <Tb> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<Tb>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	x	RESERVED

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

- <Ta> Is an arrangement specifier, encoded in "immh":

immh	<Ta>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	8H
001x	4S
01xx	2D
1xxx	RESERVED

- <Vb> Is the destination width specifier, encoded in "immh":

immh	<Vb>
0000	RESERVED
0001	B
001x	H
01xx	S
1xxx	RESERVED

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.

- <Va> Is the source width specifier, encoded in "immh":

immh	<Va>
0000	RESERVED
0001	H
001x	S
01xx	D
1xxx	RESERVED

- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

- <shift> For the scalar variant: is the right shift amount, in the range 1 to the destination operand width in bits, encoded in "immh:immb":

immh	<shift>
0000	RESERVED
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	RESERVED



For the vector variant: is the right shift amount, in the range 1 to the destination element width in bits, encoded in “immh:immb”:

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize*2) operand = V[n];
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;
boolean sat;

for e = 0 to elements-1
    element = (Int(Elem[operand, e, 2*esize], unsigned) + round_const) >> shift;
    (Elem[result, e, esize], sat) = SatQ(element, esize, unsigned);
    if sat then FPSR.QC = '1';

Vpart[d, part] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## SQRSHRUN, SQRSHRUN2

Signed saturating Rounded Shift Right Unsigned Narrow (immediate). This instruction reads each signed integer value in the vector of the source SIMD&FP register, right shifts each value by an immediate value, saturates the result to an unsigned integer value that is half the original width, places the final result into a vector, and writes the vector to the destination SIMD&FP register. The results are rounded. For truncated results, see [SQSHRUN](#).

The SQRSHRUN instruction writes the vector to the lower half of the destination register and clears the upper half, while the SQRSHRUN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.

If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	1	0	!= 0000				immb			1	0	0	0	1	1	Rn				Rd					
immh												op																			

**SQRSHRUN** <Vb><d>, <Va><n>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then UNDEFINED;
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = esize;
integer elements = 1;
integer part = 0;

integer shift = (2 * esize) - UInt(immh:immb);
boolean round = (op == '1');
```

### Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	0	!= 0000				immb			1	0	0	0	1	1	Rn				Rd					
immh												op																			

**SQRSHRUN{2}** <Vd>.<Tb>, <Vn>.<Ta>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

integer shift = (2 * esize) - UInt(immh:immb);
boolean round = (op == '1');
```

## Assembler Symbols

- 2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in "Q":

Q	2
0	[absent]
1	[present]

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

- <Tb> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<Tb>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	x	RESERVED

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

- <Ta> Is an arrangement specifier, encoded in "immh":

immh	<Ta>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	8H
001x	4S
01xx	2D
1xxx	RESERVED

- <Vb> Is the destination width specifier, encoded in "immh":

immh	<Vb>
0000	RESERVED
0001	B
001x	H
01xx	S
1xxx	RESERVED

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.

- <Va> Is the source width specifier, encoded in "immh":

immh	<Va>
0000	RESERVED
0001	H
001x	S
01xx	D
1xxx	RESERVED

- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

- <shift> For the scalar variant: is the right shift amount, in the range 1 to the destination operand width in bits, encoded in "immh:immb":

immh	<shift>
0000	RESERVED
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	RESERVED

For the vector variant: is the right shift amount, in the range 1 to the destination element width in bits, encoded in “immh:immb”:

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize*2) operand = V[n];
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;
boolean sat;

for e = 0 to elements-1
    element = (SInt(Elem[operand, e, 2*esize]) + round_const) >> shift;
    (Elem[result, e, esize], sat) = UnsignedSatQ(element, esize);
    if sat then FPSR.QC = '1';

Vpart[d, part] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SQSHL (immediate)

Signed saturating Shift Left (immediate). This instruction reads each vector element in the source SIMD&FP register, shifts each result by an immediate value, places the final result in a vector, and writes the vector to the destination SIMD&FP register. The results are truncated. For rounded results, see [UQRSHL](#).  
If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.  
Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	0	!= 0000				immb			0	1	1	1	0	1	Rn				Rd					
U									immh				op																		

SQSHL [<V><d>](#), [<V><n>](#), [#<shift>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = esize;
integer elements = 1;

integer shift = UInt(immh:immb) - esize;

boolean src_unsigned;
boolean dst_unsigned;
case op:U of
    when '00' UNDEFINED;
    when '01' src_unsigned = FALSE; dst_unsigned = TRUE;
    when '10' src_unsigned = FALSE; dst_unsigned = FALSE;
    when '11' src_unsigned = TRUE; dst_unsigned = TRUE;
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	0	!= 0000				immb			0	1	1	1	0	1	Rn				Rd					
U									immh				op																		

SQSHL <Vd>.<T>, <Vn>.<T>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3>:Q == '10' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer shift = UInt(immh:immb) - esize;

boolean src_unsigned;
boolean dst_unsigned;
case op:U of
  when '00' UNDEFINED;
  when '01' src_unsigned = FALSE; dst_unsigned = TRUE;
  when '10' src_unsigned = FALSE; dst_unsigned = FALSE;
  when '11' src_unsigned = TRUE; dst_unsigned = TRUE;
```

### Assembler Symbols

<V> Is a width specifier, encoded in “immh”:

immh	<V>
0000	RESERVED
0001	B
001x	H
01xx	S
1xxx	D

<d> Is the number of the SIMD&FP destination register, in the “Rd” field.

<n> Is the number of the first SIMD&FP source register, encoded in the “Rn” field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the “Rd” field.

<T> Is an arrangement specifier, encoded in “immh:Q”:

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the “Rn” field.

<shift> For the scalar variant: is the left shift amount, in the range 0 to the operand width in bits minus 1, encoded in “immh:immb”:

immh	<shift>
0000	RESERVED
0001	(UInt(immh:immb)-8)
001x	(UInt(immh:immb)-16)
01xx	(UInt(immh:immb)-32)
1xxx	(UInt(immh:immb)-64)

For the vector variant: is the left shift amount, in the range 0 to the element width in bits minus 1, encoded in “immh:immb”:

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(UInt(immh:immb)-8)
001x	(UInt(immh:immb)-16)
01xx	(UInt(immh:immb)-32)
1xxx	(UInt(immh:immb)-64)

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
integer element;
boolean sat;

for e = 0 to elements-1
    element = Int(Elem[operand, e, esize], src_unsigned) << shift;
    (Elem[result, e, esize], sat) = SatQ(element, esize, dst_unsigned);
    if sat then FPSR.QC = '1';

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

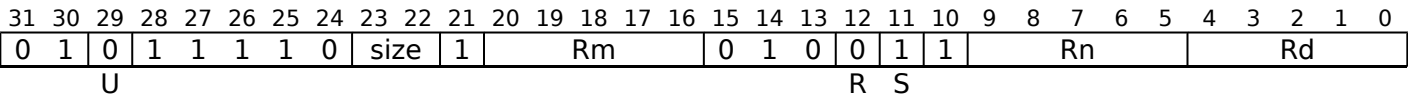
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SQSHL (register)

Signed saturating Shift Left (register). This instruction takes each element in the vector of the first source SIMD&FP register, shifts each element by a value from the least significant byte of the corresponding element of the second source SIMD&FP register, places the results in a vector, and writes the vector to the destination SIMD&FP register. If the shift value is positive, the operation is a left shift. Otherwise, it is a right shift. The results are truncated. For rounded results, see [SQRSHL](#). If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set. Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

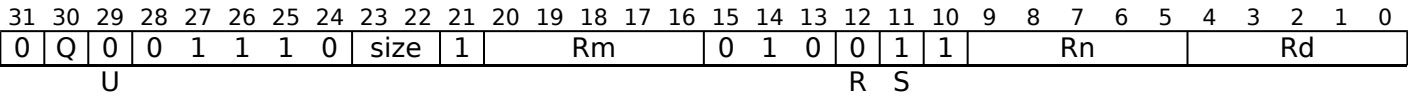
Scalar



SQSHL <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
if S == '0' && size != '11' then UNDEFINED;
```

Vector



SQSHL <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D



- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

### Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

integer round_const = 0;
integer shift;
integer element;
boolean sat;

for e = 0 to elements-1
    shift = SInt(Elem[operand2, e, esize]<7:0>);
    if rounding then
        round_const = 1 << (-shift - 1);    // 0 for left shift, 2^(n-1) for right shift
    element = (Int(Elem[operand1, e, esize], unsigned) + round_const) << shift;
    if saturating then
        (Elem[result, e, esize], sat) = SatQ(element, esize, unsigned);
        if sat then FPSR.QC = '1';
    else
        Elem[result, e, esize] = element<esize-1:0>;
V[d] = result;

```

# SQSHLU

Signed saturating Shift Left Unsigned (immediate). This instruction reads each signed integer value in the vector of the source SIMD&FP register, shifts each value by an immediate value, saturates the shifted result to an unsigned integer value, places the result in a vector, and writes the vector to the destination SIMD&FP register. The results are truncated. For rounded results, see [UQRSHL](#).  
If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.  
Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	1	0	!= 0000				immb			0	1	1	0	0	1	Rn				Rd					
U									immh				op																		

SQSHLU <V><d>, <V><n>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = esize;
integer elements = 1;

integer shift = UInt(immh:immb) - esize;

boolean src_unsigned;
boolean dst_unsigned;
case op:U of
  when '00' UNDEFINED;
  when '01' src_unsigned = FALSE; dst_unsigned = TRUE;
  when '10' src_unsigned = FALSE; dst_unsigned = FALSE;
  when '11' src_unsigned = TRUE; dst_unsigned = TRUE;
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	0	!= 0000				immb			0	1	1	0	0	1	Rn				Rd					
U									immh				op																		

SQSHLU <Vd>.<T>, <Vn>.<T>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3>:Q == '10' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer shift = UInt(immh:immb) - esize;

boolean src_unsigned;
boolean dst_unsigned;
case op:U of
  when '00' UNDEFINED;
  when '01' src_unsigned = FALSE; dst_unsigned = TRUE;
  when '10' src_unsigned = FALSE; dst_unsigned = FALSE;
  when '11' src_unsigned = TRUE; dst_unsigned = TRUE;
```

### Assembler Symbols

<V> Is a width specifier, encoded in “immh”:

immh	<V>
0000	RESERVED
0001	B
001x	H
01xx	S
1xxx	D

<d> Is the number of the SIMD&FP destination register, in the “Rd” field.

<n> Is the number of the first SIMD&FP source register, encoded in the “Rn” field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the “Rd” field.

<T> Is an arrangement specifier, encoded in “immh:Q”:

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the “Rn” field.

<shift> For the scalar variant: is the left shift amount, in the range 0 to the operand width in bits minus 1, encoded in “immh:immb”:

immh	<shift>
0000	RESERVED
0001	(UInt(immh:immb)-8)
001x	(UInt(immh:immb)-16)
01xx	(UInt(immh:immb)-32)
1xxx	(UInt(immh:immb)-64)

For the vector variant: is the left shift amount, in the range 0 to the element width in bits minus 1, encoded in “immh:immb”:

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(UInt(immh:immb)-8)
001x	(UInt(immh:immb)-16)
01xx	(UInt(immh:immb)-32)
1xxx	(UInt(immh:immb)-64)

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
integer element;
boolean sat;

for e = 0 to elements-1
    element = Int(Elem[operand, e, esize], src_unsigned) << shift;
    (Elem[result, e, esize], sat) = SatQ(element, esize, dst_unsigned);
    if sat then FPSR.QC = '1';

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## SQSHRN, SQSHRN2

Signed saturating Shift Right Narrow (immediate). This instruction reads each vector element in the source SIMD&FP register, right shifts and truncates each result by an immediate value, saturates each shifted result to a value that is half the original width, puts the final result into a vector, and writes the vector to the lower or upper half of the destination SIMD&FP register. All the values in this instruction are signed integer values. The destination vector elements are half as long as the source vector elements. For rounded results, see [SQRSHRN](#).

The SQSHRN instruction writes the vector to the lower half of the destination register and clears the upper half, while the SQSHRN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.

If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	0	!= 0000				immb			1	0	0	1	0	1	Rn				Rd					
U									immh				op																		

**SQSHRN** [<Vb><d>](#), [<Va><n>](#), [#<shift>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then UNDEFINED;
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = esize;
integer elements = 1;
integer part = 0;

integer shift = (2 * esize) - UInt(immh:immb);
boolean round = (op == '1');
boolean unsigned = (U == '1');
```

### Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	0	!= 0000				immb			1	0	0	1	0	1	Rn				Rd					
U									immh				op																		

**SQSHRN{2}** [<Vd>.<Tb>](#), [<Vn>.<Ta>](#), [#<shift>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

integer shift = (2 * esize) - UInt(immh:immb);
boolean round = (op == '1');
boolean unsigned = (U == '1');
```

## Assembler Symbols

- 2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in "Q":

Q	2
0	[absent]
1	[present]

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

- <Tb> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<Tb>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	x	RESERVED

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

- <Ta> Is an arrangement specifier, encoded in "immh":

immh	<Ta>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	8H
001x	4S
01xx	2D
1xxx	RESERVED

- <Vb> Is the destination width specifier, encoded in "immh":

immh	<Vb>
0000	RESERVED
0001	B
001x	H
01xx	S
1xxx	RESERVED

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.

- <Va> Is the source width specifier, encoded in "immh":

immh	<Va>
0000	RESERVED
0001	H
001x	S
01xx	D
1xxx	RESERVED

- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

- <shift> For the scalar variant: is the right shift amount, in the range 1 to the destination operand width in bits, encoded in "immh:immb":

immh	<shift>
0000	RESERVED
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	RESERVED

For the vector variant: is the right shift amount, in the range 1 to the destination element width in bits, encoded in “immh:immb”:

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize*2) operand = V[n];
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;
boolean sat;

for e = 0 to elements-1
    element = (Int(Elem[operand, e, 2*esize], unsigned) + round_const) >> shift;
    (Elem[result, e, esize], sat) = SatQ(element, esize, unsigned);
    if sat then FPSR.QC = '1';

Vpart[d, part] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SQSHRUN, SQSHRUN2

Signed saturating Shift Right Unsigned Narrow (immediate). This instruction reads each signed integer value in the vector of the source SIMD&FP register, right shifts each value by an immediate value, saturates the result to an unsigned integer value that is half the original width, places the final result into a vector, and writes the vector to the destination SIMD&FP register. The results are truncated. For rounded results, see [SQRSHRUN](#).

The SQSHRUN instruction writes the vector to the lower half of the destination register and clears the upper half, while the SQSHRUN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.

If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	1	0	!= 0000			immb			1	0	0	0	0	1	Rn				Rd						
immh										op																					

SQSHRUN [<Vb><d>](#), [<Va><n>](#), [#<shift>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then UNDEFINED;
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = esize;
integer elements = 1;
integer part = 0;

integer shift = (2 * esize) - UInt(immh:immb);
boolean round = (op == '1');
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	0	!= 0000				immb			1	0	0	0	0	1	Rn				Rd					
immh										op																					

SQSHRUN{2} [<Vd>.<Tb>](#), [<Vn>.<Ta>](#), [#<shift>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

integer shift = (2 * esize) - UInt(immh:immb);
boolean round = (op == '1');
```



## Assembler Symbols

- 2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in "Q":

Q	2
0	[absent]
1	[present]

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

- <Tb> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<Tb>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	x	RESERVED

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

- <Ta> Is an arrangement specifier, encoded in "immh":

immh	<Ta>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	8H
001x	4S
01xx	2D
1xxx	RESERVED

- <Vb> Is the destination width specifier, encoded in "immh":

immh	<Vb>
0000	RESERVED
0001	B
001x	H
01xx	S
1xxx	RESERVED

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.

- <Va> Is the source width specifier, encoded in "immh":

immh	<Va>
0000	RESERVED
0001	H
001x	S
01xx	D
1xxx	RESERVED

- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

- <shift> For the scalar variant: is the right shift amount, in the range 1 to the destination operand width in bits, encoded in "immh:immb":

immh	<shift>
0000	RESERVED
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	RESERVED

For the vector variant: is the right shift amount, in the range 1 to the destination element width in bits, encoded in “immh:immb”:

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize*2) operand = V[n];
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;
boolean sat;

for e = 0 to elements-1
    element = (SInt(Elem[operand, e, 2*esize]) + round_const) >> shift;
    (Elem[result, e, esize], sat) = UnsignedSatQ(element, esize);
    if sat then FPSR.QC = '1';

Vpart[d, part] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SQSUB

Signed saturating Subtract. This instruction subtracts the element values of the second source SIMD&FP register from the corresponding element values of the first source SIMD&FP register, places the results into a vector, and writes the vector to the destination SIMD&FP register.

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit `FPSR.QC` is set.

Depending on the settings in the `CPACR_EL1`, `CPTR_EL2`, and `CPTR_EL3` registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	1	0	1	1	1	1	0	size	1	Rm						0	0	1	0	1	1	Rn						Rd					
U																																	

SQSUB <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
```

Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	Q	0	0	1	1	1	0	size	1	Rm						0	0	1	0	1	1	Rn						Rd					
U																																	

SQSUB <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
integer diff;
boolean sat;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    diff = element1 - element2;
    (Elem[result, e, esize], sat) = SatQ(diff, esize, unsigned);
    if sat then FPSR.QC = '1';

V[d] = result;
```

# SQXTN, SQXTN2

Signed saturating extract Narrow. This instruction reads each vector element from the source SIMD&FP register, saturates the value to half the original width, places the result into a vector, and writes the vector to the lower or upper half of the destination SIMD&FP register. The destination vector elements are half as long as the source vector elements. All the values in this instruction are signed integer values.

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit `FPSR.QC` is set.

The `SQXTN` instruction writes the vector to the lower half of the destination register and clears the upper half, while the `SQXTN2` instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.

Depending on the settings in the `CPACR_EL1`, `CPTR_EL2`, and `CPTR_EL3` registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	size			1	0	0	0	0	1	0	1	0	0	1	0	Rn				Rd				
U																															

`SQXTN <Vb><d>, <Va><n>`

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer part = 0;
integer elements = 1;

boolean unsigned = (U == '1');
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	size			1	0	0	0	0	1	0	1	0	0	1	0	Rn				Rd				
U																															

`SQXTN{2} <Vd>.<Tb>, <Vn>.<Ta>`

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
```

## Assembler Symbols

- 2
- Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Tb> Is an arrangement specifier, encoded in "size:Q":

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<Ta> Is an arrangement specifier, encoded in "size":

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vb> Is the destination width specifier, encoded in "size":

size	<Vb>
00	B
01	H
10	S
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Va> Is the source width specifier, encoded in "size":

size	<Va>
00	H
01	S
10	D
11	RESERVED

<n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(2*datasize) operand = V[n];
bits(datasize) result;
bits(2*esize) element;
boolean sat;

for e = 0 to elements-1
    element = Elem[operand, e, 2*esize];
    (Elem[result, e, esize], sat) = Sat0(Int(element, unsigned), esize, unsigned);
    if sat then FPSR.QC = '1';

Vpart[d, part] = result;

```

# SQXTUN, SQXTUN2

Signed saturating extract Unsigned Narrow. This instruction reads each signed integer value in the vector of the source SIMD&FP register, saturates the value to an unsigned integer value that is half the original width, places the result into a vector, and writes the vector to the lower or upper half of the destination SIMD&FP register. The destination vector elements are half as long as the source vector elements.

If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

The SQXTUN instruction writes the vector to the lower half of the destination register and clears the upper half, while the SQXTUN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	size	1	0	0	0	0	1	0	0	1	0	1	0	Rn					Rd					

SQXTUN <Vb><d>, <Va><n>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer part = 0;
integer elements = 1;
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	size	1	0	0	0	0	1	0	0	1	0	1	0											

SQXTUN{2} <Vd>.<Tb>, <Vn>.<Ta>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;
```

## Assembler Symbols

- 2

Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Tb>

Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<Ta> Is an arrangement specifier, encoded in "size":

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vb> Is the destination width specifier, encoded in "size":

size	<Vb>
00	B
01	H
10	S
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Va> Is the source width specifier, encoded in "size":

size	<Va>
00	H
01	S
10	D
11	RESERVED

<n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(2*datasize) operand = V[n];
bits(datasize) result;
bits(2*esize) element;
boolean sat;

for e = 0 to elements-1
    element = Elem[operand, e, 2*esize];
    (Elem[result, e, esize], sat) = UnsignedSatQ(SInt(element), esize);
    if sat then FPSR.QC = '1';

Vpart[d, part] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

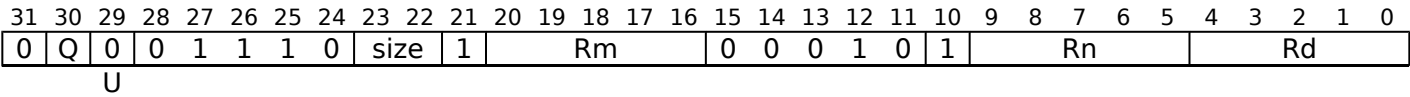


SRHADD

Signed Rounding Halving Add. This instruction adds corresponding signed integer values from the two source SIMD&FP registers, shifts each result right one bit, places the results into a vector, and writes the vector to the destination SIMD&FP register.

The results are rounded. For truncated results, see [SHADD](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



SRHADD <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

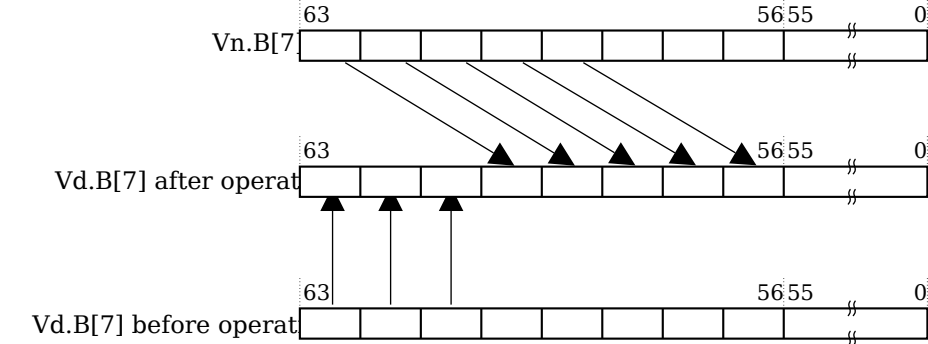
```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    Elem[result, e, esize] = (element1+element2+1)<esize:1>;

V[d] = result;
```

SRI

Shift Right and Insert (immediate). This instruction reads each vector element in the source SIMD&FP register, right shifts each vector element by an immediate value, and inserts the result into the corresponding vector element in the destination SIMD&FP register such that the new zero bits created by the shift are not inserted but retain their existing value. Bits shifted out of the right of each vector element of the source register are lost. The following figure shows an example of the operation of shift right by 3 for an 8-bit vector element.



Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	1	0	!= 0000			immb			0	1	0	0	0	1	Rn				Rd						
immh																															

SRI <V><d>, <V><n>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh<3> != '1' then UNDEFINED;
integer esize = 8 << 3;
integer datasize = esize;
integer elements = 1;

integer shift = (esize * 2) - UInt(immh:immb);
```

Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	0	!= 0000			immb			0	1	0	0	0	1	Rn				Rd						
immh																															

SRI <Vd>.<T>, <Vn>.<T>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3>:Q == '10' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer shift = (esize * 2) - UInt(immh:immb);
```

## Assembler Symbols

<V> Is a width specifier, encoded in “immh”:

immh	<V>
0xxx	RESERVED
1xxx	D

<d> Is the number of the SIMD&FP destination register, in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in “immh:Q”:

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<shift> For the scalar variant: is the right shift amount, in the range 1 to 64, encoded in “immh:immb”:

immh	<shift>
0xxx	RESERVED
1xxx	(128-UInt(immh:immb))

For the vector variant: is the right shift amount, in the range 1 to the element width in bits, encoded in “immh:immb”:

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) operand2 = V[d];
bits(datasize) result;
bits(esize) mask = LSR(Ones(esize), shift);
bits(esize) shifted;

for e = 0 to elements-1
    shifted = LSR(Elem[operand, e, esize], shift);
    Elem[result, e, esize] = (Elem[operand2, e, esize] AND NOT(mask)) OR shifted;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:

- The values of the data supplied in any of its registers.
- The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

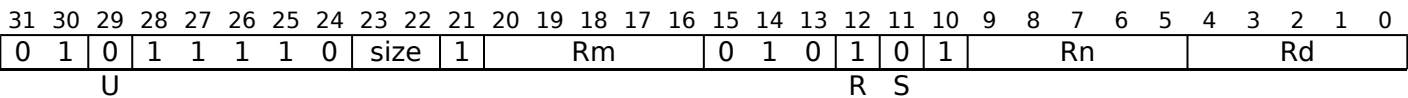
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SRSHL

Signed Rounding Shift Left (register). This instruction takes each signed integer value in the vector of the first source SIMD&FP register, shifts it by a value from the least significant byte of the corresponding element of the second source SIMD&FP register, places the results in a vector, and writes the vector to the destination SIMD&FP register. If the shift value is positive, the operation is a left shift. If the shift value is negative, it is a rounding right shift. For a truncating shift, see [SSHLL](#). Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

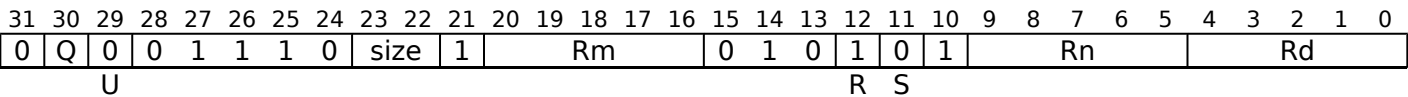
Scalar



SRSHL <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
if S == '0' && size != '11' then UNDEFINED;
```

Vector



SRSHL <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D

<d> Is the number of the SIMD&FP destination register, in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

integer round_const = 0;
integer shift;
integer element;
boolean sat;

for e = 0 to elements-1
    shift = SInt(Elem[operand2, e, esize]<7:0>);
    if rounding then
        round_const = 1 << (-shift - 1);    // 0 for left shift, 2^(n-1) for right shift
    element = (Int(Elem[operand1, e, esize], unsigned) + round_const) << shift;
    if saturating then
        (Elem[result, e, esize], sat) = SatQ(element, esize, unsigned);
        if sat then FPSR.QC = '1';
    else
        Elem[result, e, esize] = element<esize-1:0>;

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

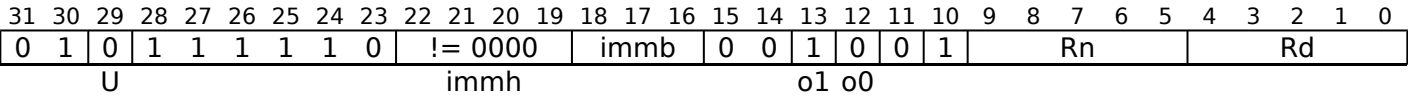
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SRRSHR

Signed Rounding Shift Right (immediate). This instruction reads each vector element in the source SIMD&FP register, right shifts each result by an immediate value, places the final result into a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are signed integer values. The results are rounded. For truncated results, see [SSHR](#).  
Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar



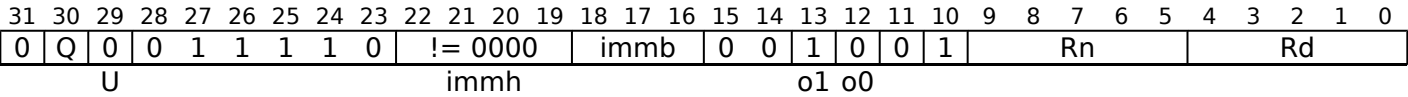
SRRSHR <V><d>, <V><n>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh<3> != '1' then UNDEFINED;
integer esize = 8 << 3;
integer datasize = esize;
integer elements = 1;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

Vector



SRRSHR <Vd>.<T>, <Vn>.<T>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3>:Q == '10' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “immh”:

immh	<V>
0xxx	RESERVED
1xxx	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.
- <shift> For the scalar variant: is the right shift amount, in the range 1 to 64, encoded in "immh:immb":

immh	<shift>
0xxx	RESERVED
1xxx	(128-UInt(immh:immb))

For the vector variant: is the right shift amount, in the range 1 to the element width in bits, encoded in "immh:immb":

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

## Operation

```

CheckFPAdvSIMDEnabled64\(\);
bits(datasize) operand = V[n];
bits(datasize) operand2;
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;

operand2 = if accumulate then V[d] else Zeros\(\);
for e = 0 to elements-1
    element = (Int(Elem[operand, e, esize], unsigned) + round_const) >> shift;
    Elem[result, e, esize] = Elem[operand2, e, esize] + element<esize-1:0>;
V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



SRSRA

Signed Rounding Shift Right and Accumulate (immediate). This instruction reads each vector element in the source SIMD&FP register, right shifts each result by an immediate value, and accumulates the final results with the vector elements of the destination SIMD&FP register. All the values in this instruction are signed integer values. The results are rounded. For truncated results, see [SSRA](#).  
Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	0	!= 0000				immb		0	0	1	1	0	1	Rn					Rd					
U									immh				o1 o0																		

SRSRA <V><d>, <V><n>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh<3> != '1' then UNDEFINED;
integer esize = 8 << 3;
integer datasize = esize;
integer elements = 1;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	0	!= 0000				immb		0	0	1	1	0	1	Rn					Rd					
U									immh				o1 o0																		

SRSRA <Vd>.<T>, <Vn>.<T>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3>:Q == '10' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “immh”:

immh	<V>
0xxx	RESERVED
1xxx	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.
- <shift> For the scalar variant: is the right shift amount, in the range 1 to 64, encoded in "immh:immb":

immh	<shift>
0xxx	RESERVED
1xxx	(128-UInt(immh:immb))

For the vector variant: is the right shift amount, in the range 1 to the element width in bits, encoded in "immh:immb":

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

## Operation

```

CheckFPAdvSIMDEnabled64\(\);
bits(datasize) operand = V[n];
bits(datasize) operand2;
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;

operand2 = if accumulate then V[d] else Zeros\(\);
for e = 0 to elements-1
    element = (Int(Elem[operand, e, esize], unsigned) + round_const) >> shift;
    Elem[result, e, esize] = Elem[operand2, e, esize] + element<esize-1:0>;
V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SSHL

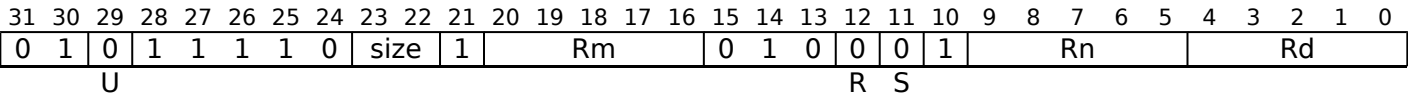
Signed Shift Left (register). This instruction takes each signed integer value in the vector of the first source SIMD&FP register, shifts each value by a value from the least significant byte of the corresponding element of the second source SIMD&FP register, places the results in a vector, and writes the vector to the destination SIMD&FP register.

If the shift value is positive, the operation is a left shift. If the shift value is negative, it is a truncating right shift. For a rounding shift, see [SRSHL](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

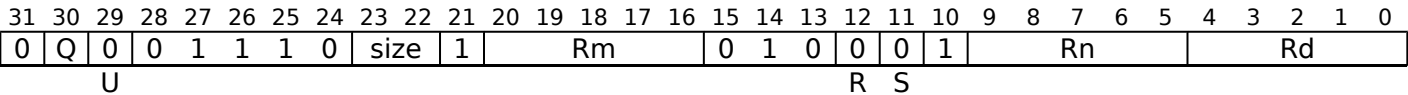
Scalar



SSHL [<V>](#)[<d>](#), [<V>](#)[<n>](#), [<V>](#)[<m>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
if S == '0' && size != '11' then UNDEFINED;
```

Vector



SSHL [<Vd>](#)[.<T>](#), [<Vn>](#)[.<T>](#), [<Vm>](#)[.<T>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
```

Assembler Symbols

[<V>](#) Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D

[<d>](#) Is the number of the SIMD&FP destination register, in the “Rd” field.

[<n>](#) Is the number of the first SIMD&FP source register, encoded in the “Rn” field.

- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

### Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

integer round_const = 0;
integer shift;
integer element;
boolean sat;

for e = 0 to elements-1
    shift = SInt(Elem[operand2, e, esize]<7:0>);
    if rounding then
        round_const = 1 << (-shift - 1);    // 0 for left shift, 2^(n-1) for right shift
    element = (Int(Elem[operand1, e, esize], unsigned) + round_const) << shift;
    if saturating then
        (Elem[result, e, esize], sat) = SatQ(element, esize, unsigned);
        if sat then FPSR.QC = '1';
    else
        Elem[result, e, esize] = element<esize-1:0>;

V[d] = result;

```

### Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

SSHLL, SSHLL2

Signed Shift Left Long (immediate). This instruction reads each vector element from the source SIMD&FP register, left shifts each vector element by the specified shift amount, places the result into a vector, and writes the vector to the destination SIMD&FP register. The destination vector elements are twice as long as the source vector elements. All the values in this instruction are signed integer values.

The SSHLL instruction extracts vector elements from the lower half of the source register, while the SSHLL2 instruction extracts vector elements from the upper half of the source register.

Depending on the settings in the CPACR EL1, CPTR EL2, and CPTR EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This instruction is used by the alias SXTL, SXTL2.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	0	!= 0000				immb			1	0	1	0	0	1	Rn				Rd					
U									immh																						

SSHLL{2} <Vd>.<Ta>, <Vn>.<Tb>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = 64;
integer part = UInt(0);
integer elements = datasize DIV esize;

integer shift = UInt(immh:immb) - esize;
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q		2
0		[absent]
1		[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “immh”:

immh	<Ta>
0000	SEE Advanced SIMD modified immediate
0001	8H
001x	4S
01xx	2D
1xxx	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “immh:Q”:

immh	Q	<Tb>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	x	RESERVED

<shift> Is the left shift amount, in the range 0 to the source element width in bits minus 1, encoded in “immh:immb”:

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(UInt(immh:immb)-8)
001x	(UInt(immh:immb)-16)
01xx	(UInt(immh:immb)-32)
1xxx	RESERVED

## Alias Conditions

Alias	Is preferred when
<a href="#">SXTL, SXTL2</a>	immb == '000' && <a href="#">BitCount</a> (immh) == 1

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = Vpart[n, part];
bits(datasize*2) result;
integer element;

for e = 0 to elements-1
    element = Int(Elem[operand, e, esize], unsigned) << shift;
    Elem[result, e, 2*esize] = element<2*esize-1:0>;

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SSHR

Signed Shift Right (immediate). This instruction reads each vector element in the source SIMD&FP register, right shifts each result by an immediate value, places the final result into a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are signed integer values. The results are truncated. For rounded results, see [SRSHR](#).  
Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	0	!= 0000				immb			0	0	0	0	0	1	Rn						Rd			
U									immh				o1			o0															

SSHR [<V><d>](#), [<V><n>](#), [#<shift>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh<3> != '1' then UNDEFINED;
integer esize = 8 << 3;
integer datasize = esize;
integer elements = 1;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	0	!= 0000				immb			0	0	0	0	0	1	Rn						Rd			
U									immh				o1			o0															

SSHR [<Vd>.<T>](#), [<Vn>.<T>](#), [#<shift>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3>:Q == '10' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

Assembler Symbols

[<V>](#) Is a width specifier, encoded in “immh”:

immh	<a href="#">&lt;V&gt;</a>
0xxx	RESERVED
1xxx	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.
- <shift> For the scalar variant: is the right shift amount, in the range 1 to 64, encoded in "immh:immb":

immh	<shift>
0xxx	RESERVED
1xxx	(128-UInt(immh:immb))

For the vector variant: is the right shift amount, in the range 1 to the element width in bits, encoded in "immh:immb":

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) operand2;
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;

operand2 = if accumulate then V[d] else Zeros();
for e = 0 to elements-1
    element = (Int(Elem[operand, e, esize], unsigned) + round_const) >> shift;
    Elem[result, e, esize] = Elem[operand2, e, esize] + element<esize-1:0>;

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

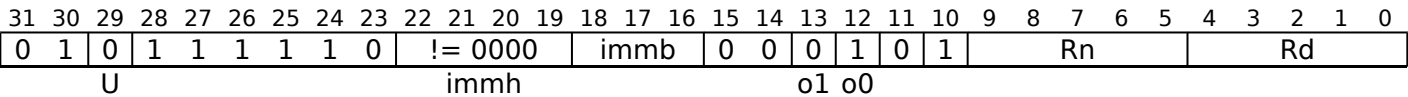


SSRA

Signed Shift Right and Accumulate (immediate). This instruction reads each vector element in the source SIMD&FP register, right shifts each result by an immediate value, and accumulates the final results with the vector elements of the destination SIMD&FP register. All the values in this instruction are signed integer values. The results are truncated. For rounded results, see [SRSRA](#).  
Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar



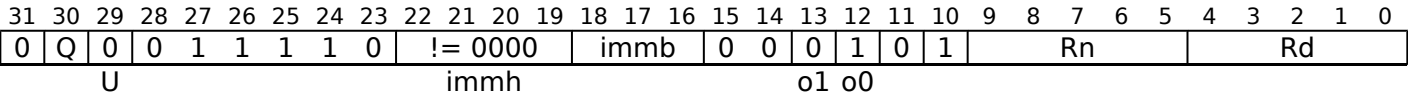
SSRA [<V><d>](#), [<V><n>](#), [#<shift>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh<3> != '1' then UNDEFINED;
integer esize = 8 << 3;
integer datasize = esize;
integer elements = 1;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

Vector



SSRA [<Vd>.<T>](#), [<Vn>.<T>](#), [#<shift>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3>:Q == '10' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

Assembler Symbols

[<V>](#) Is a width specifier, encoded in “immh”:

immh	<V>
0xxx	RESERVED
1xxx	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.
- <shift> For the scalar variant: is the right shift amount, in the range 1 to 64, encoded in "immh:immb":

immh	<shift>
0xxx	RESERVED
1xxx	(128-UInt(immh:immb))

For the vector variant: is the right shift amount, in the range 1 to the element width in bits, encoded in "immh:immb":

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) operand2;
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;

operand2 = if accumulate then V[d] else Zeros();
for e = 0 to elements-1
    element = (Int(Elem[operand, e, esize], unsigned) + round_const) >> shift;
    Elem[result, e, esize] = Elem[operand2, e, esize] + element<esize-1:0>;
V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

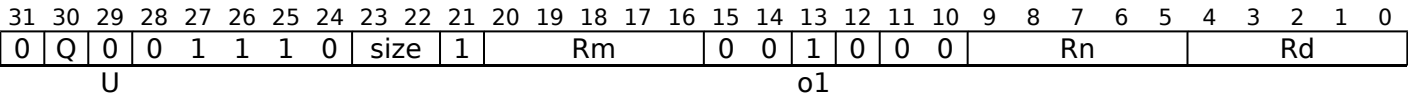
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SSUBL, SSUBL2

Signed Subtract Long. This instruction subtracts each vector element in the lower or upper half of the second source SIMD&FP register from the corresponding vector element of the first source SIMD&FP register, places the results into a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are signed integer values. The destination vector elements are twice as long as the source vector elements.

The SSUBL instruction extracts each source vector from the lower half of each source register, while the SSUBL2 instruction extracts each source vector from the upper half of each source register.

Depending on the settings in the CPACR EL1, CPTR EL2, and CPTR EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



SSUBL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean sub_op = (o1 == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q 2	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
integer element1;
integer element2;
integer sum;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    if sub_op then
        sum = element1 - element2;
    else
        sum = element1 + element2;
    Elem[result, e, 2*esize] = sum<2*esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

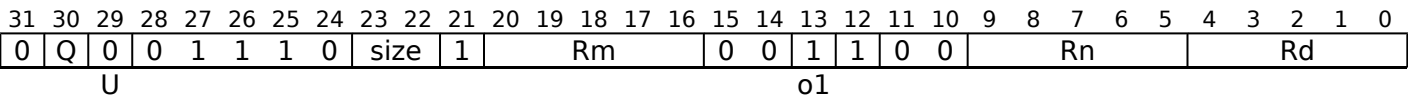
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SSUBW, SSUBW2

Signed Subtract Wide. This instruction subtracts each vector element in the lower or upper half of the second source SIMD&FP register from the corresponding vector element in the first source SIMD&FP register, places the result in a vector, and writes the vector to the SIMD&FP destination register. All the values in this instruction are signed integer values.

The SSUBW instruction extracts the second source vector from the lower half of the second source register, while the SSUBW2 instruction extracts the second source vector from the upper half of the second source register.

Depending on the settings in the CPACR EL1, CPTR EL2, and CPTR EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



SSUBW{2} <Vd>.<Ta>, <Vn>.<Ta>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean sub_op = (o1 == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q2	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(2*datasize) operand1 = V[n];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
integer element1;
integer element2;
integer sum;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, 2*esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    if sub_op then
        sum = element1 - element2;
    else
        sum = element1 + element2;
    Elem[result, e, 2*esize] = sum<2*esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## ST1 (multiple structures)

Store multiple single-element structures from one, two, three, or four registers. This instruction stores elements to memory from one, two, three, or four SIMD&FP registers, without interleaving. Every element of each register is stored.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

### No offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	0	0	0	0	0	0	0	0	0	x	x	1	x	size		Rn				Rt					
L										opcode																					

### One register (opcode == 0111)

ST1 { <Vt>.<T> }, [<Xn|SP>]

### Two registers (opcode == 1010)

ST1 { <Vt>.<T>, <Vt2>.<T> }, [<Xn|SP>]

### Three registers (opcode == 0110)

ST1 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T> }, [<Xn|SP>]

### Four registers (opcode == 0010)

ST1 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T>, <Vt4>.<T> }, [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

### Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	0	1	0	0	Rm				x	x	1	x	size			Rn				Rt					
L										opcode																					

**One register, immediate offset (Rm == 11111 && opcode == 0111)**

```
ST1 { <Vt>.<T> }, [<Xn|SP>], <imm>
```

**One register, register offset (Rm != 11111 && opcode == 0111)**

```
ST1 { <Vt>.<T> }, [<Xn|SP>], <Xm>
```

**Two registers, immediate offset (Rm == 11111 && opcode == 1010)**

```
ST1 { <Vt>.<T>, <Vt2>.<T> }, [<Xn|SP>], <imm>
```

**Two registers, register offset (Rm != 11111 && opcode == 1010)**

```
ST1 { <Vt>.<T>, <Vt2>.<T> }, [<Xn|SP>], <Xm>
```

**Three registers, immediate offset (Rm == 11111 && opcode == 0110)**

```
ST1 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T> }, [<Xn|SP>], <imm>
```

**Three registers, register offset (Rm != 11111 && opcode == 0110)**

```
ST1 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T> }, [<Xn|SP>], <Xm>
```

**Four registers, immediate offset (Rm == 11111 && opcode == 0010)**

```
ST1 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T>, <Vt4>.<T> }, [<Xn|SP>], <imm>
```

**Four registers, register offset (Rm != 11111 && opcode == 0010)**

```
ST1 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T>, <Vt4>.<T> }, [<Xn|SP>], <Xm>
```

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

**Assembler Symbols**

<Vt> Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	1D
11	1	2D

<Vt2> Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.

<Vt3> Is the name of the third SIMD&FP register to be transferred, encoded as "Rt" plus 2 modulo 32.

<Vt4> Is the name of the fourth SIMD&FP register to be transferred, encoded as "Rt" plus 3 modulo 32.

<Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.



<imm> For the one register, immediate offset variant: is the post-index immediate offset, encoded in "Q":

Q	<imm>
0	#8
1	#16

For the two registers, immediate offset variant: is the post-index immediate offset, encoded in "Q":

Q	<imm>
0	#16
1	#32

For the three registers, immediate offset variant: is the post-index immediate offset, encoded in "Q":

Q	<imm>
0	#24
1	#48

For the four registers, immediate offset variant: is the post-index immediate offset, encoded in "Q":

Q	<imm>
0	#32
1	#64

<Xm> Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

## Shared Decode

```
MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << UInt(size);
integer elements = datasize DIV esize;

integer rpt;    // number of iterations
integer selem;  // structure elements

case opcode of
  when '0000' rpt = 1; selem = 4;    // LD/ST4 (4 registers)
  when '0010' rpt = 4; selem = 1;    // LD/ST1 (4 registers)
  when '0100' rpt = 1; selem = 3;    // LD/ST3 (3 registers)
  when '0110' rpt = 3; selem = 1;    // LD/ST1 (3 registers)
  when '0111' rpt = 1; selem = 1;    // LD/ST1 (1 register)
  when '1000' rpt = 1; selem = 2;    // LD/ST2 (2 registers)
  when '1010' rpt = 2; selem = 1;    // LD/ST1 (2 registers)
  otherwise UNDEFINED;

// .1D format only permitted with LD1 & ST1
if size:Q == '110' && selem != 1 then UNDEFINED;
```

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(datasize) rval;
integer tt;
constant integer ebytes = esize DIV 8;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
for r = 0 to rpt-1
    for e = 0 to elements-1
        tt = (t + r) MOD 32;
        for s = 0 to selem-1
            rval = V[tt];
            if memop == MemOp_LOAD then
                Elem[rval, e, esize] = Mem[address+offs, ebytes, AccType_VEC];
                V[tt] = rval;
            else // memop == MemOp_STORE
                Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, e, esize];
                offs = offs + ebytes;
                tt = (tt + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## ST1 (single structure)

Store a single-element structure from one lane of one register. This instruction stores the specified element of a SIMD&FP register to memory.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

### No offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	0	0	0	0	0	0	0	0	x	x	0	S	size	Rn					Rt					
L										R	opcode																				

### 8-bit (opcode == 000)

ST1 { <Vt>.B }[<index>], [<Xn|SP>]

### 16-bit (opcode == 010 && size == x0)

ST1 { <Vt>.H }[<index>], [<Xn|SP>]

### 32-bit (opcode == 100 && size == 00)

ST1 { <Vt>.S }[<index>], [<Xn|SP>]

### 64-bit (opcode == 100 && S == 0 && size == 01)

ST1 { <Vt>.D }[<index>], [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

### Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	1	0	0	Rm					x	x	0	S	size	Rn					Rt					
L										R	opcode																				

**8-bit, immediate offset (Rm == 11111 && opcode == 000)**

```
ST1 { <Vt>.B }[<index>], [<Xn|SP>], #1
```

**8-bit, register offset (Rm != 11111 && opcode == 000)**

```
ST1 { <Vt>.B }[<index>], [<Xn|SP>], <Xm>
```

**16-bit, immediate offset (Rm == 11111 && opcode == 010 && size == x0)**

```
ST1 { <Vt>.H }[<index>], [<Xn|SP>], #2
```

**16-bit, register offset (Rm != 11111 && opcode == 010 && size == x0)**

```
ST1 { <Vt>.H }[<index>], [<Xn|SP>], <Xm>
```

**32-bit, immediate offset (Rm == 11111 && opcode == 100 && size == 00)**

```
ST1 { <Vt>.S }[<index>], [<Xn|SP>], #4
```

**32-bit, register offset (Rm != 11111 && opcode == 100 && size == 00)**

```
ST1 { <Vt>.S }[<index>], [<Xn|SP>], <Xm>
```

**64-bit, immediate offset (Rm == 11111 && opcode == 100 && S == 0 && size == 01)**

```
ST1 { <Vt>.D }[<index>], [<Xn|SP>], #8
```

**64-bit, register offset (Rm != 11111 && opcode == 100 && S == 0 && size == 01)**

```
ST1 { <Vt>.D }[<index>], [<Xn|SP>], <Xm>
```

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

**Assembler Symbols**

<Vt>	Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
<index>	For the 8-bit variant: is the element index, encoded in "Q:S:size". For the 16-bit variant: is the element index, encoded in "Q:S:size<1>". For the 32-bit variant: is the element index, encoded in "Q:S". For the 64-bit variant: is the element index, encoded in "Q".
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

## Shared Decode

```
integer init_scale = UInt(opcode<2:1>);
integer scale = init_scale;
integer selem = UInt(opcode<0>:R) + 1;
boolean replicate = FALSE;
integer index;

case scale of
  when 3
    // load and replicate
    if L == '0' || S == '1' then UNDEFINED;
    scale = UInt(size);
    replicate = TRUE;
  when 0
    index = UInt(Q:S:size);    // B[0-15]
  when 1
    if size<0> == '1' then UNDEFINED;
    index = UInt(Q:S:size<1>); // H[0-7]
  when 2
    if size<1> == '1' then UNDEFINED;
    if size<0> == '0' then
      index = UInt(Q:S);    // S[0-3]
    else
      if S == '1' then UNDEFINED;
      index = UInt(Q);    // D[0-1]
      scale = 3;
MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << scale;
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(128) rval;
bits(esize) element;
constant integer ebytes = esize DIV 8;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
if replicate then
    // load and replicate to all elements
    for s = 0 to selem-1
        element = Mem[address+offs, ebytes, AccType_VEC];
        // replicate to fill 128- or 64-bit register
        V[t] = Replicate(element, datasize DIV esize);
        offs = offs + ebytes;
        t = (t + 1) MOD 32;
else
    // load/store one element per register
    for s = 0 to selem-1
        rval = V[t];
        if memop == MemOp_LOAD then
            // insert into one lane of 128-bit register
            Elem[rval, index, esize] = Mem[address+offs, ebytes, AccType_VEC];
            V[t] = rval;
        else // memop == MemOp_STORE
            // extract from one lane of 128-bit register
            Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, index, esize];
            offs = offs + ebytes;
            t = (t + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## ST2 (multiple structures)

Store multiple 2-element structures from two registers. This instruction stores multiple 2-element structures from two SIMD&FP registers to memory, with interleaving. Every element of each register is stored.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

### No offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	size	Rn				Rt						
L										opcode																					

ST2 { <Vt>.<T>, <Vt2>.<T> }, [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

### Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	0	1	0	0	Rm				1	0	0	0	size			Rn				Rt					
L										opcode																					

### Immediate offset (Rm == 11111)

ST2 { <Vt>.<T>, <Vt2>.<T> }, [<Xn|SP>], <imm>

### Register offset (Rm != 11111)

ST2 { <Vt>.<T>, <Vt2>.<T> }, [<Xn|SP>], <Xm>

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

## Assembler Symbols

<Vt> Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vt2> Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.

- <Xn|SP>      Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm>        Is the post-index immediate offset, encoded in "Q":

Q	<imm>
0	#16
1	#32
- <Xm>        Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

Shared Decode

```
MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << UInt(size);
integer elements = datasize DIV esize;

integer rpt;      // number of iterations
integer selem;    // structure elements

case opcode of
  when '0000' rpt = 1; selem = 4;      // LD/ST4 (4 registers)
  when '0010' rpt = 4; selem = 1;      // LD/ST1 (4 registers)
  when '0100' rpt = 1; selem = 3;      // LD/ST3 (3 registers)
  when '0110' rpt = 3; selem = 1;      // LD/ST1 (3 registers)
  when '0111' rpt = 1; selem = 1;      // LD/ST1 (1 register)
  when '1000' rpt = 1; selem = 2;      // LD/ST2 (2 registers)
  when '1010' rpt = 2; selem = 1;      // LD/ST1 (2 registers)
  otherwise UNDEFINED;

// .1D format only permitted with LD1 & ST1
if size:Q == '110' && selem != 1 then UNDEFINED;
```



## Operation

```
CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(datasize) rval;
integer tt;
constant integer ebytes = esize DIV 8;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
for r = 0 to rpt-1
    for e = 0 to elements-1
        tt = (t + r) MOD 32;
        for s = 0 to selem-1
            rval = V[tt];
            if memop == MemOp_LOAD then
                Elem[rval, e, esize] = Mem[address+offs, ebytes, AccType_VEC];
                V[tt] = rval;
            else // memop == MemOp_STORE
                Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, e, esize];
                offs = offs + ebytes;
                tt = (tt + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## ST2 (single structure)

Store single 2-element structure from one lane of two registers. This instruction stores a 2-element structure to memory from corresponding elements of two SIMD&FP registers.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

### No offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	Q	0	0	1	1	0	1	0	0	1	0	0	0	0	0	x	x	0	S	size	Rn						Rt					
L										R	opcode																					

### 8-bit (opcode == 000)

ST2 { <Vt>.B, <Vt2>.B }[<index>], [<Xn|SP>]

### 16-bit (opcode == 010 && size == x0)

ST2 { <Vt>.H, <Vt2>.H }[<index>], [<Xn|SP>]

### 32-bit (opcode == 100 && size == 00)

ST2 { <Vt>.S, <Vt2>.S }[<index>], [<Xn|SP>]

### 64-bit (opcode == 100 && S == 0 && size == 01)

ST2 { <Vt>.D, <Vt2>.D }[<index>], [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

### Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	1	0	1	Rm					x	x	0	S	size	Rn			Rt							
L										R	opcode																				

**8-bit, immediate offset (Rm == 11111 && opcode == 000)**

```
ST2 { <Vt>.B, <Vt2>.B }[<index>], [<Xn|SP>], #2
```

**8-bit, register offset (Rm != 11111 && opcode == 000)**

```
ST2 { <Vt>.B, <Vt2>.B }[<index>], [<Xn|SP>], <Xm>
```

**16-bit, immediate offset (Rm == 11111 && opcode == 010 && size == x0)**

```
ST2 { <Vt>.H, <Vt2>.H }[<index>], [<Xn|SP>], #4
```

**16-bit, register offset (Rm != 11111 && opcode == 010 && size == x0)**

```
ST2 { <Vt>.H, <Vt2>.H }[<index>], [<Xn|SP>], <Xm>
```

**32-bit, immediate offset (Rm == 11111 && opcode == 100 && size == 00)**

```
ST2 { <Vt>.S, <Vt2>.S }[<index>], [<Xn|SP>], #8
```

**32-bit, register offset (Rm != 11111 && opcode == 100 && size == 00)**

```
ST2 { <Vt>.S, <Vt2>.S }[<index>], [<Xn|SP>], <Xm>
```

**64-bit, immediate offset (Rm == 11111 && opcode == 100 && S == 0 && size == 01)**

```
ST2 { <Vt>.D, <Vt2>.D }[<index>], [<Xn|SP>], #16
```

**64-bit, register offset (Rm != 11111 && opcode == 100 && S == 0 && size == 01)**

```
ST2 { <Vt>.D, <Vt2>.D }[<index>], [<Xn|SP>], <Xm>
```

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

**Assembler Symbols**

<Vt>	Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
<Vt2>	Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.
<index>	For the 8-bit variant: is the element index, encoded in "Q:S:size". For the 16-bit variant: is the element index, encoded in "Q:S:size<1>". For the 32-bit variant: is the element index, encoded in "Q:S". For the 64-bit variant: is the element index, encoded in "Q".
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

## Shared Decode

```
integer init_scale = UInt(opcode<2:1>);
integer scale = init_scale;
integer selem = UInt(opcode<0>:R) + 1;
boolean replicate = FALSE;
integer index;

case scale of
  when 3
    // load and replicate
    if L == '0' || S == '1' then UNDEFINED;
    scale = UInt(size);
    replicate = TRUE;
  when 0
    index = UInt(Q:S:size);    // B[0-15]
  when 1
    if size<0> == '1' then UNDEFINED;
    index = UInt(Q:S:size<1>); // H[0-7]
  when 2
    if size<1> == '1' then UNDEFINED;
    if size<0> == '0' then
      index = UInt(Q:S);    // S[0-3]
    else
      if S == '1' then UNDEFINED;
      index = UInt(Q);    // D[0-1]
      scale = 3;
MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << scale;
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(128) rval;
bits(esize) element;
constant integer ebytes = esize DIV 8;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
if replicate then
    // load and replicate to all elements
    for s = 0 to selem-1
        element = Mem[address+offs, ebytes, AccType_VEC];
        // replicate to fill 128- or 64-bit register
        V[t] = Replicate(element, datasize DIV esize);
        offs = offs + ebytes;
        t = (t + 1) MOD 32;
else
    // load/store one element per register
    for s = 0 to selem-1
        rval = V[t];
        if memop == MemOp_LOAD then
            // insert into one lane of 128-bit register
            Elem[rval, index, esize] = Mem[address+offs, ebytes, AccType_VEC];
            V[t] = rval;
        else // memop == MemOp_STORE
            // extract from one lane of 128-bit register
            Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, index, esize];
            offs = offs + ebytes;
            t = (t + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## ST3 (multiple structures)

Store multiple 3-element structures from three registers. This instruction stores multiple 3-element structures to memory from three SIMD&FP registers, with interleaving. Every element of each register is stored. Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

### No offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	size	Rn				Rt						
L										opcode																					

ST3 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T> }, [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

### Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	0	1	0	0	Rm					0	1	0	0	size			Rn					Rt			
L										opcode																					

### Immediate offset (Rm == 11111)

ST3 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T> }, [<Xn|SP>], <imm>

### Register offset (Rm != 11111)

ST3 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T> }, [<Xn|SP>], <Xm>

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

### Assembler Symbols

- <Vt> Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vt2> Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.

- <Vt3> Is the name of the third SIMD&FP register to be transferred, encoded as "Rt" plus 2 modulo 32.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the post-index immediate offset, encoded in "Q":
- | Q | <imm> |
|---|-------|
| 0 | #24   |
| 1 | #48   |
- <Xm> Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

## Shared Decode

```
MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << UInt(size);
integer elements = datasize DIV esize;

integer rpt;    // number of iterations
integer selem;  // structure elements

case opcode of
  when '0000' rpt = 1; selem = 4;    // LD/ST4 (4 registers)
  when '0010' rpt = 4; selem = 1;    // LD/ST1 (4 registers)
  when '0100' rpt = 1; selem = 3;    // LD/ST3 (3 registers)
  when '0110' rpt = 3; selem = 1;    // LD/ST1 (3 registers)
  when '0111' rpt = 1; selem = 1;    // LD/ST1 (1 register)
  when '1000' rpt = 1; selem = 2;    // LD/ST2 (2 registers)
  when '1010' rpt = 2; selem = 1;    // LD/ST1 (2 registers)
  otherwise UNDEFINED;

// .1D format only permitted with LD1 & ST1
if size:Q == '110' && selem != 1 then UNDEFINED;
```

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(datasize) rval;
integer tt;
constant integer ebytes = esize DIV 8;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
for r = 0 to rpt-1
    for e = 0 to elements-1
        tt = (t + r) MOD 32;
        for s = 0 to selem-1
            rval = V[tt];
            if memop == MemOp_LOAD then
                Elem[rval, e, esize] = Mem[address+offs, ebytes, AccType_VEC];
                V[tt] = rval;
            else // memop == MemOp_STORE
                Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, e, esize];
                offs = offs + ebytes;
                tt = (tt + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



## ST3 (single structure)

Store single 3-element structure from one lane of three registers. This instruction stores a 3-element structure to memory from corresponding elements of three SIMD&FP registers.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

### No offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	0	0	0	0	0	0	0	0	x	x	1	S	size	Rn			Rt							
L										R										opcode											

### 8-bit (opcode == 001)

ST3 { <Vt>.B, <Vt2>.B, <Vt3>.B }[<index>], [<Xn|SP>]

### 16-bit (opcode == 011 && size == x0)

ST3 { <Vt>.H, <Vt2>.H, <Vt3>.H }[<index>], [<Xn|SP>]

### 32-bit (opcode == 101 && size == 00)

ST3 { <Vt>.S, <Vt2>.S, <Vt3>.S }[<index>], [<Xn|SP>]

### 64-bit (opcode == 101 && S == 0 && size == 01)

ST3 { <Vt>.D, <Vt2>.D, <Vt3>.D }[<index>], [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

### Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	1	0	0	Rm					x	x	1	S	size	Rn					Rt					
L										R	opcode																				

**8-bit, immediate offset (Rm == 11111 && opcode == 001)**

```
ST3 { <Vt>.B, <Vt2>.B, <Vt3>.B }[<index>], [<Xn|SP>], #3
```

**8-bit, register offset (Rm != 11111 && opcode == 001)**

```
ST3 { <Vt>.B, <Vt2>.B, <Vt3>.B }[<index>], [<Xn|SP>], <Xm>
```

**16-bit, immediate offset (Rm == 11111 && opcode == 011 && size == x0)**

```
ST3 { <Vt>.H, <Vt2>.H, <Vt3>.H }[<index>], [<Xn|SP>], #6
```

**16-bit, register offset (Rm != 11111 && opcode == 011 && size == x0)**

```
ST3 { <Vt>.H, <Vt2>.H, <Vt3>.H }[<index>], [<Xn|SP>], <Xm>
```

**32-bit, immediate offset (Rm == 11111 && opcode == 101 && size == 00)**

```
ST3 { <Vt>.S, <Vt2>.S, <Vt3>.S }[<index>], [<Xn|SP>], #12
```

**32-bit, register offset (Rm != 11111 && opcode == 101 && size == 00)**

```
ST3 { <Vt>.S, <Vt2>.S, <Vt3>.S }[<index>], [<Xn|SP>], <Xm>
```

**64-bit, immediate offset (Rm == 11111 && opcode == 101 && S == 0 && size == 01)**

```
ST3 { <Vt>.D, <Vt2>.D, <Vt3>.D }[<index>], [<Xn|SP>], #24
```

**64-bit, register offset (Rm != 11111 && opcode == 101 && S == 0 && size == 01)**

```
ST3 { <Vt>.D, <Vt2>.D, <Vt3>.D }[<index>], [<Xn|SP>], <Xm>
```

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

**Assembler Symbols**

<Vt>	Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
<Vt2>	Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.
<Vt3>	Is the name of the third SIMD&FP register to be transferred, encoded as "Rt" plus 2 modulo 32.
<index>	For the 8-bit variant: is the element index, encoded in "Q:S:size". For the 16-bit variant: is the element index, encoded in "Q:S:size<1>". For the 32-bit variant: is the element index, encoded in "Q:S". For the 64-bit variant: is the element index, encoded in "Q".
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

## Shared Decode

```
integer init_scale = UInt(opcode<2:1>);
integer scale = init_scale;
integer selem = UInt(opcode<0>:R) + 1;
boolean replicate = FALSE;
integer index;

case scale of
  when 3
    // load and replicate
    if L == '0' || S == '1' then UNDEFINED;
    scale = UInt(size);
    replicate = TRUE;
  when 0
    index = UInt(Q:S:size);    // B[0-15]
  when 1
    if size<0> == '1' then UNDEFINED;
    index = UInt(Q:S:size<1>); // H[0-7]
  when 2
    if size<1> == '1' then UNDEFINED;
    if size<0> == '0' then
      index = UInt(Q:S);    // S[0-3]
    else
      if S == '1' then UNDEFINED;
      index = UInt(Q);    // D[0-1]
      scale = 3;
MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << scale;
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(128) rval;
bits(esize) element;
constant integer ebytes = esize DIV 8;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
if replicate then
    // load and replicate to all elements
    for s = 0 to selem-1
        element = Mem[address+offs, ebytes, AccType_VEC];
        // replicate to fill 128- or 64-bit register
        V[t] = Replicate(element, datasize DIV esize);
        offs = offs + ebytes;
        t = (t + 1) MOD 32;
else
    // load/store one element per register
    for s = 0 to selem-1
        rval = V[t];
        if memop == MemOp_LOAD then
            // insert into one lane of 128-bit register
            Elem[rval, index, esize] = Mem[address+offs, ebytes, AccType_VEC];
            V[t] = rval;
        else // memop == MemOp_STORE
            // extract from one lane of 128-bit register
            Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, index, esize];
            offs = offs + ebytes;
            t = (t + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## ST4 (multiple structures)

Store multiple 4-element structures from four registers. This instruction stores multiple 4-element structures to memory from four SIMD&FP registers, with interleaving. Every element of each register is stored. Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

### No offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	size	Rn				Rt						
L										opcode																					

ST4 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T>, <Vt4>.<T> }, [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

### Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	0	1	0	0	Rm				0	0	0	0	size	Rn				Rt							
L										opcode																					

### Immediate offset (Rm == 11111)

ST4 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T>, <Vt4>.<T> }, [<Xn|SP>], <imm>

### Register offset (Rm != 11111)

ST4 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T>, <Vt4>.<T> }, [<Xn|SP>], <Xm>

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

### Assembler Symbols

- <Vt> Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vt2> Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.

- <Vt3> Is the name of the third SIMD&FP register to be transferred, encoded as "Rt" plus 2 modulo 32.
- <Vt4> Is the name of the fourth SIMD&FP register to be transferred, encoded as "Rt" plus 3 modulo 32.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the post-index immediate offset, encoded in "Q":
 

Q	<imm>
0	#32
1	#64
- <Xm> Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

Shared Decode

```

MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << UInt(size);
integer elements = datasize DIV esize;

integer rpt;    // number of iterations
integer selem;  // structure elements

case opcode of
  when '0000' rpt = 1; selem = 4;    // LD/ST4 (4 registers)
  when '0010' rpt = 4; selem = 1;    // LD/ST1 (4 registers)
  when '0100' rpt = 1; selem = 3;    // LD/ST3 (3 registers)
  when '0110' rpt = 3; selem = 1;    // LD/ST1 (3 registers)
  when '0111' rpt = 1; selem = 1;    // LD/ST1 (1 register)
  when '1000' rpt = 1; selem = 2;    // LD/ST2 (2 registers)
  when '1010' rpt = 2; selem = 1;    // LD/ST1 (2 registers)
  otherwise UNDEFINED;

// .LD format only permitted with LD1 & ST1
if size:Q == '110' && selem != 1 then UNDEFINED;

```

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(datasize) rval;
integer tt;
constant integer ebytes = esize DIV 8;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
for r = 0 to rpt-1
    for e = 0 to elements-1
        tt = (t + r) MOD 32;
        for s = 0 to selem-1
            rval = V[tt];
            if memop == MemOp_LOAD then
                Elem[rval, e, esize] = Mem[address+offs, ebytes, AccType_VEC];
                V[tt] = rval;
            else // memop == MemOp_STORE
                Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, e, esize];
                offs = offs + ebytes;
                tt = (tt + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

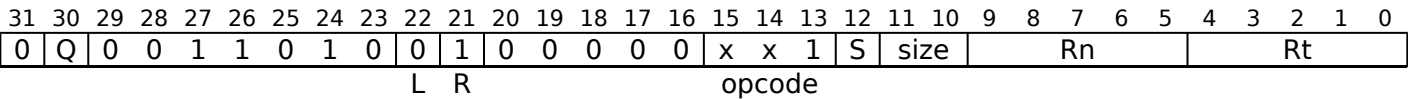
## ST4 (single structure)

Store single 4-element structure from one lane of four registers. This instruction stores a 4-element structure to memory from corresponding elements of four SIMD&FP registers.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

### No offset



### 8-bit (opcode == 001)

ST4 { <Vt>.B, <Vt2>.B, <Vt3>.B, <Vt4>.B }[<index>], [<Xn|SP>]

### 16-bit (opcode == 011 && size == x0)

ST4 { <Vt>.H, <Vt2>.H, <Vt3>.H, <Vt4>.H }[<index>], [<Xn|SP>]

### 32-bit (opcode == 101 && size == 00)

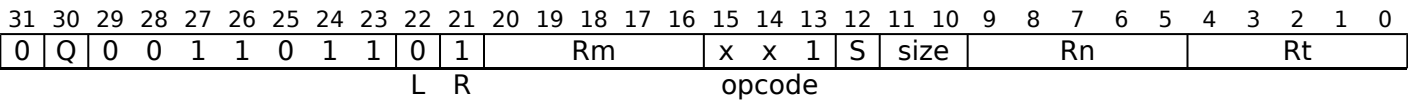
ST4 { <Vt>.S, <Vt2>.S, <Vt3>.S, <Vt4>.S }[<index>], [<Xn|SP>]

### 64-bit (opcode == 101 && S == 0 && size == 01)

ST4 { <Vt>.D, <Vt2>.D, <Vt3>.D, <Vt4>.D }[<index>], [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

### Post-index





### 8-bit, immediate offset (Rm == 11111 && opcode == 001)

ST4 { <Vt>.B, <Vt2>.B, <Vt3>.B, <Vt4>.B }[<index>], [<Xn|SP>], #4

### 8-bit, register offset (Rm != 11111 && opcode == 001)

ST4 { <Vt>.B, <Vt2>.B, <Vt3>.B, <Vt4>.B }[<index>], [<Xn|SP>], <Xm>

### 16-bit, immediate offset (Rm == 11111 && opcode == 011 && size == x0)

ST4 { <Vt>.H, <Vt2>.H, <Vt3>.H, <Vt4>.H }[<index>], [<Xn|SP>], #8

### 16-bit, register offset (Rm != 11111 && opcode == 011 && size == x0)

ST4 { <Vt>.H, <Vt2>.H, <Vt3>.H, <Vt4>.H }[<index>], [<Xn|SP>], <Xm>

### 32-bit, immediate offset (Rm == 11111 && opcode == 101 && size == 00)

ST4 { <Vt>.S, <Vt2>.S, <Vt3>.S, <Vt4>.S }[<index>], [<Xn|SP>], #16

### 32-bit, register offset (Rm != 11111 && opcode == 101 && size == 00)

ST4 { <Vt>.S, <Vt2>.S, <Vt3>.S, <Vt4>.S }[<index>], [<Xn|SP>], <Xm>

### 64-bit, immediate offset (Rm == 11111 && opcode == 101 && S == 0 && size == 01)

ST4 { <Vt>.D, <Vt2>.D, <Vt3>.D, <Vt4>.D }[<index>], [<Xn|SP>], #32

### 64-bit, register offset (Rm != 11111 && opcode == 101 && S == 0 && size == 01)

ST4 { <Vt>.D, <Vt2>.D, <Vt3>.D, <Vt4>.D }[<index>], [<Xn|SP>], <Xm>

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

## Assembler Symbols

<Vt>	Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
<Vt2>	Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.
<Vt3>	Is the name of the third SIMD&FP register to be transferred, encoded as "Rt" plus 2 modulo 32.
<Vt4>	Is the name of the fourth SIMD&FP register to be transferred, encoded as "Rt" plus 3 modulo 32.
<index>	For the 8-bit variant: is the element index, encoded in "Q:S:size". For the 16-bit variant: is the element index, encoded in "Q:S:size<1>". For the 32-bit variant: is the element index, encoded in "Q:S". For the 64-bit variant: is the element index, encoded in "Q".
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

## Shared Decode

```
integer init_scale = UInt(opcode<2:1>);
integer scale = init_scale;
integer selem = UInt(opcode<0>:R) + 1;
boolean replicate = FALSE;
integer index;

case scale of
  when 3
    // load and replicate
    if L == '0' || S == '1' then UNDEFINED;
    scale = UInt(size);
    replicate = TRUE;
  when 0
    index = UInt(Q:S:size);    // B[0-15]
  when 1
    if size<0> == '1' then UNDEFINED;
    index = UInt(Q:S:size<1>); // H[0-7]
  when 2
    if size<1> == '1' then UNDEFINED;
    if size<0> == '0' then
      index = UInt(Q:S);    // S[0-3]
    else
      if S == '1' then UNDEFINED;
      index = UInt(Q);    // D[0-1]
      scale = 3;
MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << scale;
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(128) rval;
bits(esize) element;
constant integer ebytes = esize DIV 8;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
if replicate then
    // load and replicate to all elements
    for s = 0 to selem-1
        element = Mem[address+offs, ebytes, AccType_VEC];
        // replicate to fill 128- or 64-bit register
        V[t] = Replicate(element, datasize DIV esize);
        offs = offs + ebytes;
        t = (t + 1) MOD 32;
else
    // load/store one element per register
    for s = 0 to selem-1
        rval = V[t];
        if memop == MemOp_LOAD then
            // insert into one lane of 128-bit register
            Elem[rval, index, esize] = Mem[address+offs, ebytes, AccType_VEC];
            V[t] = rval;
        else // memop == MemOp_STORE
            // extract from one lane of 128-bit register
            Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, index, esize];
            offs = offs + ebytes;
            t = (t + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

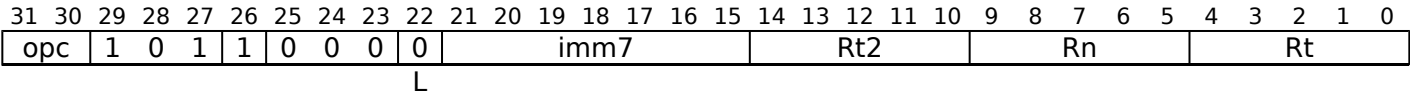
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# STNP (SIMD&FP)

Store Pair of SIMD&FP registers, with Non-temporal hint. This instruction stores a pair of SIMD&FP registers to memory, issuing a hint to the memory system that the access is non-temporal. The address used for the store is calculated from an address from a base register value and an immediate offset. For information about non-temporal pair instructions, see *Load/Store SIMD and Floating-point Non-temporal pair*. Depending on the settings in the *CPACR EL1*, *CPTR EL2*, and *CPTR EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## 32-bit (opc == 00)

STNP <St1>, <St2>, [<Xn|SP>{, #<imm>}]

## 64-bit (opc == 01)

STNP <Dt1>, <Dt2>, [<Xn|SP>{, #<imm>}]

## 128-bit (opc == 10)

STNP <Qt1>, <Qt2>, [<Xn|SP>{, #<imm>}]

// Empty.

## Assembler Symbols

- <Dt1> Is the 64-bit name of the first SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Dt2> Is the 64-bit name of the second SIMD&FP register to be transferred, encoded in the "Rt2" field.
- <Qt1> Is the 128-bit name of the first SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Qt2> Is the 128-bit name of the second SIMD&FP register to be transferred, encoded in the "Rt2" field.
- <St1> Is the 32-bit name of the first SIMD&FP register to be transferred, encoded in the "Rt" field.
- <St2> Is the 32-bit name of the second SIMD&FP register to be transferred, encoded in the "Rt2" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> For the 32-bit variant: is the optional signed immediate byte offset, a multiple of 4 in the range -256 to 252, defaulting to 0 and encoded in the "imm7" field as <imm>/4.  
For the 64-bit variant: is the optional signed immediate byte offset, a multiple of 8 in the range -512 to 504, defaulting to 0 and encoded in the "imm7" field as <imm>/8.  
For the 128-bit variant: is the optional signed immediate byte offset, a multiple of 16 in the range -1024 to 1008, defaulting to 0 and encoded in the "imm7" field as <imm>/16.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer t2 = UInt(Rt2);
if opc == '11' then UNDEFINED;
integer scale = 2 + UInt(opc);
integer datasize = 8 << scale;
bits(64) offset = LSL(SignExtend(imm7, 64), scale);
boolean tag_checked = n != 31;
```

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(datasize) data1;
bits(datasize) data2;
constant integer dbytes = datasize DIV 8;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data1 = V[t];
data2 = V[t2];
Mem[address, dbytes, AccType_VECSTREAM] = data1;
Mem[address+dbytes, dbytes, AccType_VECSTREAM] = data2;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

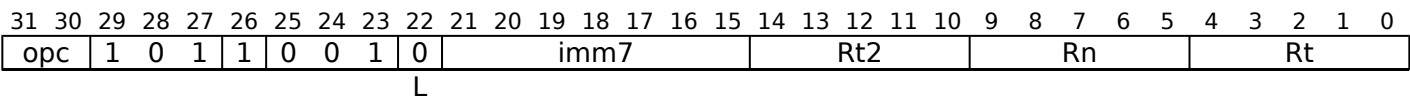
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# STP (SIMD&FP)

Store Pair of SIMD&FP registers. This instruction stores a pair of SIMD&FP registers to memory. The address used for the store is calculated from a base register value and an immediate offset.  
Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Signed offset](#)

## Post-index



### 32-bit (opc == 00)

STP <St1>, <St2>, [<Xn|SP>], #<imm>

### 64-bit (opc == 01)

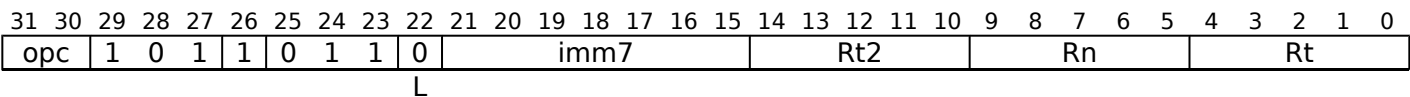
STP <Dt1>, <Dt2>, [<Xn|SP>], #<imm>

### 128-bit (opc == 10)

STP <Qt1>, <Qt2>, [<Xn|SP>], #<imm>

boolean wback = TRUE;  
boolean postindex = TRUE;

## Pre-index



### 32-bit (opc == 00)

STP <St1>, <St2>, [<Xn|SP>, #<imm>]!

### 64-bit (opc == 01)

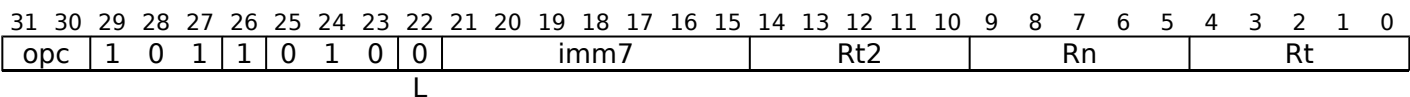
STP <Dt1>, <Dt2>, [<Xn|SP>, #<imm>]!

### 128-bit (opc == 10)

STP <Qt1>, <Qt2>, [<Xn|SP>, #<imm>]!

boolean wback = TRUE;  
boolean postindex = FALSE;

## Signed offset



### 32-bit (opc == 00)

```
STP <St1>, <St2>, [<Xn|SP>{, #<imm>}]
```

### 64-bit (opc == 01)

```
STP <Dt1>, <Dt2>, [<Xn|SP>{, #<imm>}]
```

### 128-bit (opc == 10)

```
STP <Qt1>, <Qt2>, [<Xn|SP>{, #<imm>}]
```

```
boolean wback = FALSE;  
boolean postindex = FALSE;
```

## Assembler Symbols

<Dt1>	Is the 64-bit name of the first SIMD&FP register to be transferred, encoded in the "Rt" field.
<Dt2>	Is the 64-bit name of the second SIMD&FP register to be transferred, encoded in the "Rt2" field.
<Qt1>	Is the 128-bit name of the first SIMD&FP register to be transferred, encoded in the "Rt" field.
<Qt2>	Is the 128-bit name of the second SIMD&FP register to be transferred, encoded in the "Rt2" field.
<St1>	Is the 32-bit name of the first SIMD&FP register to be transferred, encoded in the "Rt" field.
<St2>	Is the 32-bit name of the second SIMD&FP register to be transferred, encoded in the "Rt2" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<imm>	For the 32-bit post-index and 32-bit pre-index variant: is the signed immediate byte offset, a multiple of 4 in the range -256 to 252, encoded in the "imm7" field as <imm>/4.  For the 32-bit signed offset variant: is the optional signed immediate byte offset, a multiple of 4 in the range -256 to 252, defaulting to 0 and encoded in the "imm7" field as <imm>/4.  For the 64-bit post-index and 64-bit pre-index variant: is the signed immediate byte offset, a multiple of 8 in the range -512 to 504, encoded in the "imm7" field as <imm>/8.  For the 64-bit signed offset variant: is the optional signed immediate byte offset, a multiple of 8 in the range -512 to 504, defaulting to 0 and encoded in the "imm7" field as <imm>/8.  For the 128-bit post-index and 128-bit pre-index variant: is the signed immediate byte offset, a multiple of 16 in the range -1024 to 1008, encoded in the "imm7" field as <imm>/16.  For the 128-bit signed offset variant: is the optional signed immediate byte offset, a multiple of 16 in the range -1024 to 1008, defaulting to 0 and encoded in the "imm7" field as <imm>/16.

## Shared Decode

```
integer n = UInt(Rn);  
integer t = UInt(Rt);  
integer t2 = UInt(Rt2);  
if opc == '11' then UNDEFINED;  
integer scale = 2 + UInt(opc);  
integer datasize = 8 << scale;  
bits(64) offset = LSL(SignExtend(imm7, 64), scale);  
boolean tag_checked = wback || n != 31;
```

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(datasize) data1;
bits(datasize) data2;
constant integer dbytes = datasize DIV 8;

if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

data1 = V[t];
data2 = V[t2];
Mem[address, dbytes, AccType_VEC] = data1;
Mem[address+dbytes, dbytes, AccType_VEC] = data2;

if wback then
    if postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



## STR (immediate, SIMD&FP)

Store SIMD&FP register (immediate offset). This instruction stores a single SIMD&FP register to memory. The address that is used for the store is calculated from a base register value and an immediate offset. Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Unsigned offset](#)

### Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size	1	1	1	1	0	0	x	0	0	imm9											0	1	Rn				Rt				
opc																															

#### 8-bit (size == 00 && opc == 00)

STR <Bt>, [<Xn|SP>], #<sim>

#### 16-bit (size == 01 && opc == 00)

STR <Ht>, [<Xn|SP>], #<sim>

#### 32-bit (size == 10 && opc == 00)

STR <St>, [<Xn|SP>], #<sim>

#### 64-bit (size == 11 && opc == 00)

STR <Dt>, [<Xn|SP>], #<sim>

#### 128-bit (size == 00 && opc == 10)

STR <Qt>, [<Xn|SP>], #<sim>

```
boolean wback = TRUE;
boolean postindex = TRUE;
integer scale = UInt(opc<l>:size);
if scale > 4 then UNDEFINED;
bits(64) offset = SignExtend(imm9, 64);
```

### Pre-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size	1	1	1	1	0	0	x	0	0	imm9											1	1	Rn				Rt				
opc																															

8-bit (size == 00 && opc == 00)

```
STR <Bt>, [<Xn|SP>, #<sim>]!
```

16-bit (size == 01 && opc == 00)

```
STR <Ht>, [<Xn|SP>, #<sim>]!
```

32-bit (size == 10 && opc == 00)

```
STR <St>, [<Xn|SP>, #<sim>]!
```

64-bit (size == 11 && opc == 00)

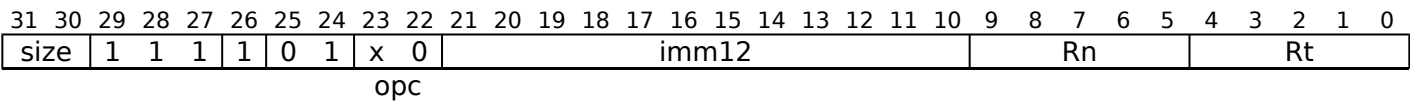
```
STR <Dt>, [<Xn|SP>, #<sim>]!
```

128-bit (size == 00 && opc == 10)

```
STR <Qt>, [<Xn|SP>, #<sim>]!
```

```
boolean wback = TRUE;
boolean postindex = FALSE;
integer scale = UInt(opc<l>:size);
if scale > 4 then UNDEFINED;
bits(64) offset = SignExtend(imm9, 64);
```

Unsigned offset



8-bit (size == 00 && opc == 00)

```
STR <Bt>, [<Xn|SP>{, #<pimm>}]
```

16-bit (size == 01 && opc == 00)

```
STR <Ht>, [<Xn|SP>{, #<pimm>}]
```

32-bit (size == 10 && opc == 00)

```
STR <St>, [<Xn|SP>{, #<pimm>}]
```

64-bit (size == 11 && opc == 00)

```
STR <Dt>, [<Xn|SP>{, #<pimm>}]
```

128-bit (size == 00 && opc == 10)

```
STR <Qt>, [<Xn|SP>{, #<pimm>}]
```

```
boolean wback = FALSE;
boolean postindex = FALSE;
integer scale = UInt(opc<l>:size);
if scale > 4 then UNDEFINED;
bits(64) offset = LSL(ZeroExtend(imm12, 64), scale);
```

## Assembler Symbols

<Bt>	Is the 8-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
<Dt>	Is the 64-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
<Ht>	Is the 16-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
<Qt>	Is the 128-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
<St>	Is the 32-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<sim>	Is the signed immediate byte offset, in the range -256 to 255, encoded in the "imm9" field.
<pimm>	For the 8-bit variant: is the optional positive immediate byte offset, in the range 0 to 4095, defaulting to 0 and encoded in the "imm12" field.  For the 16-bit variant: is the optional positive immediate byte offset, a multiple of 2 in the range 0 to 8190, defaulting to 0 and encoded in the "imm12" field as <pimm>/2.  For the 32-bit variant: is the optional positive immediate byte offset, a multiple of 4 in the range 0 to 16380, defaulting to 0 and encoded in the "imm12" field as <pimm>/4.  For the 64-bit variant: is the optional positive immediate byte offset, a multiple of 8 in the range 0 to 32760, defaulting to 0 and encoded in the "imm12" field as <pimm>/8.  For the 128-bit variant: is the optional positive immediate byte offset, a multiple of 16 in the range 0 to 65520, defaulting to 0 and encoded in the "imm12" field as <pimm>/16.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
MemOp memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = 8 << scale;
boolean tag_checked = memop != MemOp_PREFETCH && (wback || n != 31);
```

## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();
bits(64) address;
bits(datasize) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

case memop of
    when MemOp_STORE
        data = V[t];
        Mem[address, datasize DIV 8, AccType_VEC] = data;

    when MemOp_LOAD
        data = Mem[address, datasize DIV 8, AccType_VEC];
        V[t] = data;

if wback then
    if postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# STR (register, SIMD&FP)

Store SIMD&FP register (register offset). This instruction stores a single SIMD&FP register to memory. The address that is used for the store is calculated from a base register value and an offset register value. The offset can be optionally shifted and extended.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size	1	1	1	1	0	0	x	0	1	Rm						option			S	1	0	Rn						Rt			
opc																															

8-fsreg,STR-8-fsreg (size == 00 && opc == 00 && option != 011)

STR <Bt>, [<Xn|SP>, (<Wm>|<Xm>), <extend> {<amount>}]

8-fsreg,STR-8-fsreg (size == 00 && opc == 00 && option == 011)

STR <Bt>, [<Xn|SP>, <Xm>{, LSL <amount>}]

16-fsreg,STR-16-fsreg (size == 01 && opc == 00)

STR <Ht>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]

32-fsreg,STR-32-fsreg (size == 10 && opc == 00)

STR <St>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]

64-fsreg,STR-64-fsreg (size == 11 && opc == 00)

STR <Dt>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]

128-fsreg,STR-128-fsreg (size == 00 && opc == 10)

STR <Qt>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]

```
integer scale = UInt(opc<1>:size);
if scale > 4 then UNDEFINED;
if option<1> == '0' then UNDEFINED;    // sub-word index
ExtendType extend_type = DecodeRegExtend(option);
integer shift = if S == '1' then scale else 0;
```

## Assembler Symbols

- <Bt> Is the 8-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Dt> Is the 64-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Ht> Is the 16-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Qt> Is the 128-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
- <St> Is the 32-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Wm> When option<0> is set to 0, is the 32-bit name of the general-purpose index register, encoded in the "Rm" field.
- <Xm> When option<0> is set to 1, is the 64-bit name of the general-purpose index register, encoded in the "Rm" field.

<extend> For the 8-bit variant: is the index extend specifier, encoded in “option”:

option	<extend>
010	UXTW
110	SXTW
111	SXTX

For the 128-bit, 16-bit, 32-bit and 64-bit variant: is the index extend/shift specifier, defaulting to LSL, and which must be omitted for the LSL option when <amount> is omitted. encoded in “option”:

option	<extend>
010	UXTW
011	LSL
110	SXTW
111	SXTX

<amount> For the 8-bit variant: is the index shift amount, it must be #0, encoded in "S" as 0 if omitted, or as 1 if present.

For the 16-bit variant: is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in “S”:

S	<amount>
0	#0
1	#1

For the 32-bit variant: is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in “S”:

S	<amount>
0	#0
1	#2

For the 64-bit variant: is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in “S”:

S	<amount>
0	#0
1	#3

For the 128-bit variant: is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in “S”:

S	<amount>
0	#0
1	#4

Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer m = UInt(Rm);
MemOp memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = 8 << scale;
boolean tag_checked = memop != MemOp_PREFETCH;
```

## Operation

```
bits(64) offset = ExtendReg(m, extend_type, shift);
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();
bits(64) address;
bits(datasize) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

case memop of
    when MemOp_STORE
        data = V[t];
        Mem[address, datasize DIV 8, AccType_VEC] = data;

    when MemOp_LOAD
        data = Mem[address, datasize DIV 8, AccType_VEC];
        V[t] = data;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# STUR (SIMD&FP)

Store SIMD&FP register (unscaled offset). This instruction stores a single SIMD&FP register to memory. The address that is used for the store is calculated from a base register value and an optional immediate offset.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size		1	1	1	1	0	0	x	0	0	imm9									0	0	Rn				Rt					
opc																															

## 8-bit (size == 00 && opc == 00)

STUR <Bt>, [<Xn|SP>{, #<sim>}]

## 16-bit (size == 01 && opc == 00)

STUR <Ht>, [<Xn|SP>{, #<sim>}]

## 32-bit (size == 10 && opc == 00)

STUR <St>, [<Xn|SP>{, #<sim>}]

## 64-bit (size == 11 && opc == 00)

STUR <Dt>, [<Xn|SP>{, #<sim>}]

## 128-bit (size == 00 && opc == 10)

STUR <Qt>, [<Xn|SP>{, #<sim>}]

```
integer scale = UInt(opc<1>:size);
if scale > 4 then UNDEFINED;
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Bt> Is the 8-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Dt> Is the 64-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Ht> Is the 16-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Qt> Is the 128-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
- <St> Is the 32-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
MemOp memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = 8 << scale;
boolean tag_checked = memop != MemOp_PREFETCH && (n != 31);
```



## Operation

```
if HaveMTE2Ext() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();
bits(64) address;
bits(datasize) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

case memop of
    when MemOp_STORE
        data = V[t];
        Mem[address, datasize DIV 8, AccType_VEC] = data;

    when MemOp_LOAD
        data = Mem[address, datasize DIV 8, AccType_VEC];
        V[t] = data;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

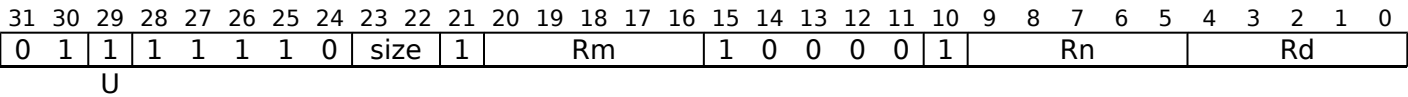
SUB (vector)

Subtract (vector). This instruction subtracts each vector element in the second source SIMD&FP register from the corresponding vector element in the first source SIMD&FP register, places the result into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

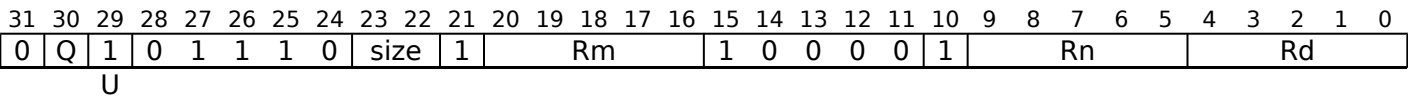
Scalar



SUB <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean sub_op = (U == '1');
```

Vector



SUB <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean sub_op = (U == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    if sub_op then
        Elem[result, e, esize] = element1 - element2;
    else
        Elem[result, e, esize] = element1 + element2;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

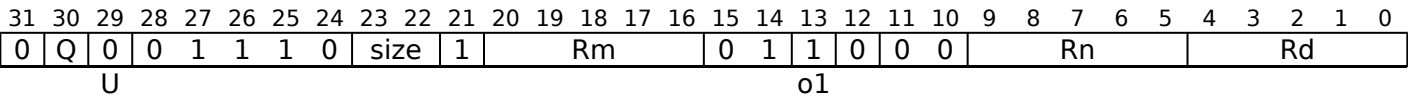
SUBHN, SUBHN2

Subtract returning High Narrow. This instruction subtracts each vector element in the second source SIMD&FP register from the corresponding vector element in the first source SIMD&FP register, places the most significant half of the result into a vector, and writes the vector to the lower or upper half of the destination SIMD&FP register. All the values in this instruction are signed integer values.

The results are truncated. For rounded results, see *RSUBHN*.

The SUBHN instruction writes the vector to the lower half of the destination register and clears the upper half, while the SUBHN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



SUBHN{2} <Vd>.<Tb>, <Vn>.<Ta>, <Vm>.<Ta>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean sub_op = (o1 == '1');
boolean round = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(2*datasize) operand1 = V[n];
bits(2*datasize) operand2 = V[m];
bits(datasize) result;
integer round_const = if round then 1 << (esize - 1) else 0;
bits(2*esize) element1;
bits(2*esize) element2;
bits(2*esize) sum;

for e = 0 to elements-1
    element1 = Elem[operand1, e, 2*esize];
    element2 = Elem[operand2, e, 2*esize];
    if sub_op then
        sum = element1 - element2;
    else
        sum = element1 + element2;
    sum = sum + round_const;
    Elem[result, e, esize] = sum<2*esize-1:esize>;

Vpart[d, part] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

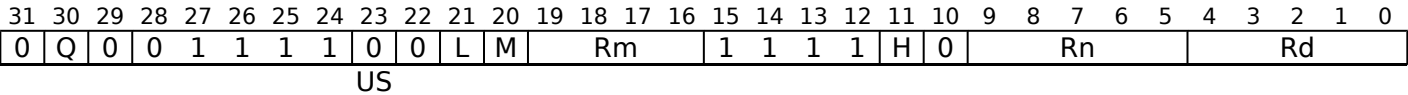
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SUDOT (by element)

Dot product index form with signed and unsigned integers. This instruction performs the dot product of the four signed 8-bit integer values in each 32-bit element of the first source register with the four unsigned 8-bit integer values in an indexed 32-bit element of the second source register, accumulating the result into the corresponding 32-bit element of the destination vector.

From Armv8.2 to Armv8.5, this is an OPTIONAL instruction. From Armv8.6 it is mandatory for implementations that include Advanced SIMD to support it. [ID\\_AA64ISAR1\\_EL1](#).I8MM indicates whether this instruction is supported.

Vector  
(FEAT\_I8MM)



SUDOT <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.4B[<index>]

```
if !HaveInt8MatMulExt() then UNDEFINED;
boolean op1_unsigned = (US == '1');
boolean op2_unsigned = (US == '0');
integer n = UInt(Rn);
integer m = UInt(M:Rm);
integer d = UInt(Rd);
integer i = UInt(H:L);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV 32;
```

Assembler Symbols

- <Vd>

Is the name of the SIMD&FP third source and destination register, encoded in the "Rd" field.
- <Ta>

Is an arrangement specifier, encoded in "Q":

Q	<Ta>
0	2S
1	4S
- <Vn>

Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Tb>

Is an arrangement specifier, encoded in "Q":

Q	<Tb>
0	8B
1	16B
- <Vm>

Is the name of the second SIMD&FP source register, encoded in the "M:Rm" fields.
- <index>

Is the immediate index of a quadruplet of four 8-bit elements in the range 0 to 3, encoded in the "H:L" fields.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(128) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;

for e = 0 to elements-1
    bits(32) res = Elem[operand3, e, 32];
    for b = 0 to 3
        integer element1 = Int(Elem[operand1, 4*e+b, 8], op1_unsigned);
        integer element2 = Int(Elem[operand2, 4*i+b, 8], op2_unsigned);
        res = res + element1 * element2;
    Elem[result, e, 32] = res;
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SUQADD

Signed saturating Accumulate of Unsigned value. This instruction adds the unsigned integer values of the vector elements in the source SIMD&FP register to corresponding signed integer values of the vector elements in the destination SIMD&FP register, and writes the resulting signed integer values to the destination SIMD&FP register. If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit *FPSR.QC* is set.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	size	1	0	0	0	0	0	0	0	0	1	1	1	0	Rn				Rd					
U																															

SUQADD <V><d>, <V><n>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;

boolean unsigned = (U == '1');
```

Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	size	1	0	0	0	0	0	0	0	0	1	1	1	0	Rn				Rd					
U																															

SUQADD <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.



<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;

bits(datasize) operand2 = V[d];
integer op1;
integer op2;
boolean sat;

for e = 0 to elements-1
    op1 = Int(Elem[operand, e, esize], !unsigned);
    op2 = Int(Elem[operand2, e, esize], unsigned);
    (Elem[result, e, esize], sat) = SatQ(op1 + op2, esize, unsigned);
    if sat then FPSR.QC = '1';
V[d] = result;
```

SXTL, SXTL2

Signed extend Long. This instruction duplicates each vector element in the lower or upper half of the source SIMD&FP register into a vector, and writes the vector to the destination SIMD&FP register. The destination vector elements are twice as long as the source vector elements. All the values in this instruction are signed integer values. The SXTL instruction extracts the source vector from the lower half of the source register, while the SXTL2 instruction extracts the source vector from the upper half of the source register. Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This is an alias of SSHLL, SSHLL2. This means:

- The encodings in this description are named to match the encodings of SSHLL, SSHLL2.
- The description of SSHLL, SSHLL2 gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	0	!= 0000				0	0	0	1	0	1	0	0	1	Rn				Rd					
U									immh				immb																		

SXTL{2} <Vd>.<Ta>, <Vn>.<Tb>

is equivalent to

SSHLL{2} <Vd>.<Ta>, <Vn>.<Tb>, #0

and is the preferred disassembly when BitCount(immh) == 1.

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q		2
0		[absent]
1		[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “immh”:

immh	<Ta>
0000	SEE Advanced SIMD modified immediate
0001	8H
001x	4S
01xx	2D
1xxx	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “immh:Q”:

immh	Q	<Tb>
0000	x	SEE Advanced SIMD modified immediate
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	x	RESERVED

## Operation

The description of [SSHLL](#), [SSHLL2](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

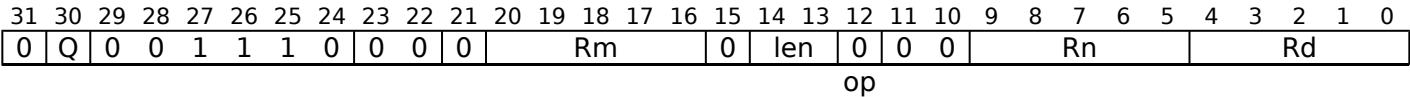
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

TBL

Table vector Lookup. This instruction reads each value from the vector elements in the index source SIMD&FP register, uses each result as an index to perform a lookup in a table of bytes that is described by one to four source table SIMD&FP registers, places the lookup result in a vector, and writes the vector to the destination SIMD&FP register. If an index is out of range for the table, the result for that lookup is 0. If more than one source register is used to describe the table, the first source register describes the lowest bytes of the table.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Two register table (len == 01)

TBL <Vd>.<Ta>, { <Vn>.16B, <Vn+1>.16B }, <Vm>.<Ta>

Three register table (len == 10)

TBL <Vd>.<Ta>, { <Vn>.16B, <Vn+1>.16B, <Vn+2>.16B }, <Vm>.<Ta>

Four register table (len == 11)

TBL <Vd>.<Ta>, { <Vn>.16B, <Vn+1>.16B, <Vn+2>.16B, <Vn+3>.16B }, <Vm>.<Ta>

Single register table (len == 00)

TBL <Vd>.<Ta>, { <Vn>.16B }, <Vm>.<Ta>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV 8;
integer regs = UInt(len) + 1;
boolean is_tbl = (op == '0');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Ta> Is an arrangement specifier, encoded in "Q":

Q	<Ta>
0	8B
1	16B
- <Vn> For the four register table, three register table and two register table variant: is the name of the first SIMD&FP table register, encoded in the "Rn" field.  
For the single register table variant: is the name of the SIMD&FP table register, encoded in the "Rn" field.
- <Vn+1> Is the name of the second SIMD&FP table register, encoded as "Rn" plus 1 modulo 32.
- <Vn+2> Is the name of the third SIMD&FP table register, encoded as "Rn" plus 2 modulo 32.
- <Vn+3> Is the name of the fourth SIMD&FP table register, encoded as "Rn" plus 3 modulo 32.
- <Vm> Is the name of the SIMD&FP index register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) indices = V[m];
bits(128*regs) table = Zeros();
bits(datasize) result;
integer index;

// Create table from registers
for i = 0 to regs-1
    table<128*i+127:128*i> = V[n];
    n = (n + 1) MOD 32;

result = if is_tbl then Zeros() else V[d];
for i = 0 to elements-1
    index = UInt(Elem[indices, i, 8]);
    if index < 16 * regs then
        Elem[result, i, 8] = Elem[table, index, 8];

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

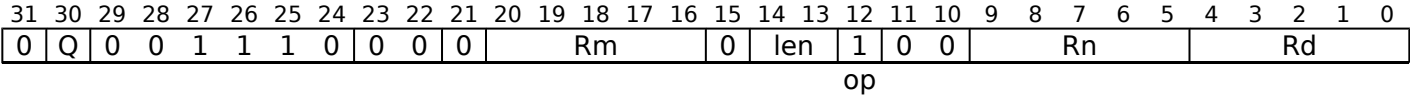
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

TBX

Table vector lookup extension. This instruction reads each value from the vector elements in the index source SIMD&FP register, uses each result as an index to perform a lookup in a table of bytes that is described by one to four source table SIMD&FP registers, places the lookup result in a vector, and writes the vector to the destination SIMD&FP register. If an index is out of range for the table, the existing value in the vector element of the destination register is left unchanged. If more than one source register is used to describe the table, the first source register describes the lowest bytes of the table.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Two register table (len == 01)

TBX <Vd>.<Ta>, { <Vn>.16B, <Vn+1>.16B }, <Vm>.<Ta>

Three register table (len == 10)

TBX <Vd>.<Ta>, { <Vn>.16B, <Vn+1>.16B, <Vn+2>.16B }, <Vm>.<Ta>

Four register table (len == 11)

TBX <Vd>.<Ta>, { <Vn>.16B, <Vn+1>.16B, <Vn+2>.16B, <Vn+3>.16B }, <Vm>.<Ta>

Single register table (len == 00)

TBX <Vd>.<Ta>, { <Vn>.16B }, <Vm>.<Ta>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV 8;
integer regs = UInt(len) + 1;
boolean is_tbl = (op == '0');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Ta> Is an arrangement specifier, encoded in "Q":

Q	<Ta>
0	8B
1	16B
- <Vn> For the four register table, three register table and two register table variant: is the name of the first SIMD&FP table register, encoded in the "Rn" field.  
For the single register table variant: is the name of the SIMD&FP table register, encoded in the "Rn" field.
- <Vn+1> Is the name of the second SIMD&FP table register, encoded as "Rn" plus 1 modulo 32.
- <Vn+2> Is the name of the third SIMD&FP table register, encoded as "Rn" plus 2 modulo 32.
- <Vn+3> Is the name of the fourth SIMD&FP table register, encoded as "Rn" plus 3 modulo 32.
- <Vm> Is the name of the SIMD&FP index register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) indices = V[m];
bits(128*regs) table = Zeros();
bits(datasize) result;
integer index;

// Create table from registers
for i = 0 to regs-1
    table<128*i+127:128*i> = V[n];
    n = (n + 1) MOD 32;

result = if is_tbl then Zeros() else V[d];
for i = 0 to elements-1
    index = UInt(Elem[indices, i, 8]);
    if index < 16 * regs then
        Elem[result, i, 8] = Elem[table, index, 8];

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

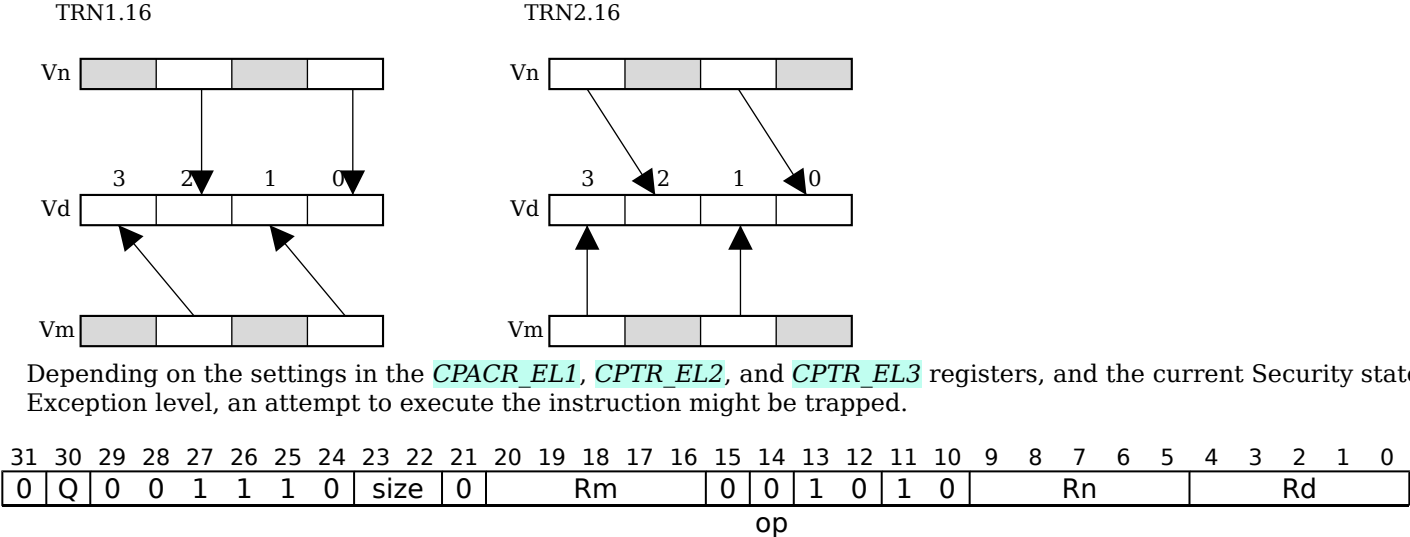
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

TRN1

Transpose vectors (primary). This instruction reads corresponding even-numbered vector elements from the two source SIMD&FP registers, starting at zero, places each result into consecutive elements of a vector, and writes the vector to the destination SIMD&FP register. Vector elements from the first source register are placed into even-numbered elements of the destination vector, starting at zero, while vector elements from the second source register are placed into odd-numbered elements of the destination vector.

By using this instruction with TRN2, a 2 x 2 matrix can be transposed.

The following figure shows an example of the operation of TRN1 and TRN2 halfword operations where Q = 0.



TRN1 <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
integer part = UInt(op);
integer pairs = elements DIV 2;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.



## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

for p = 0 to pairs-1
    Elem[result, 2*p+0, esize] = Elem[operand1, 2*p+part, esize];
    Elem[result, 2*p+1, esize] = Elem[operand2, 2*p+part, esize];

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

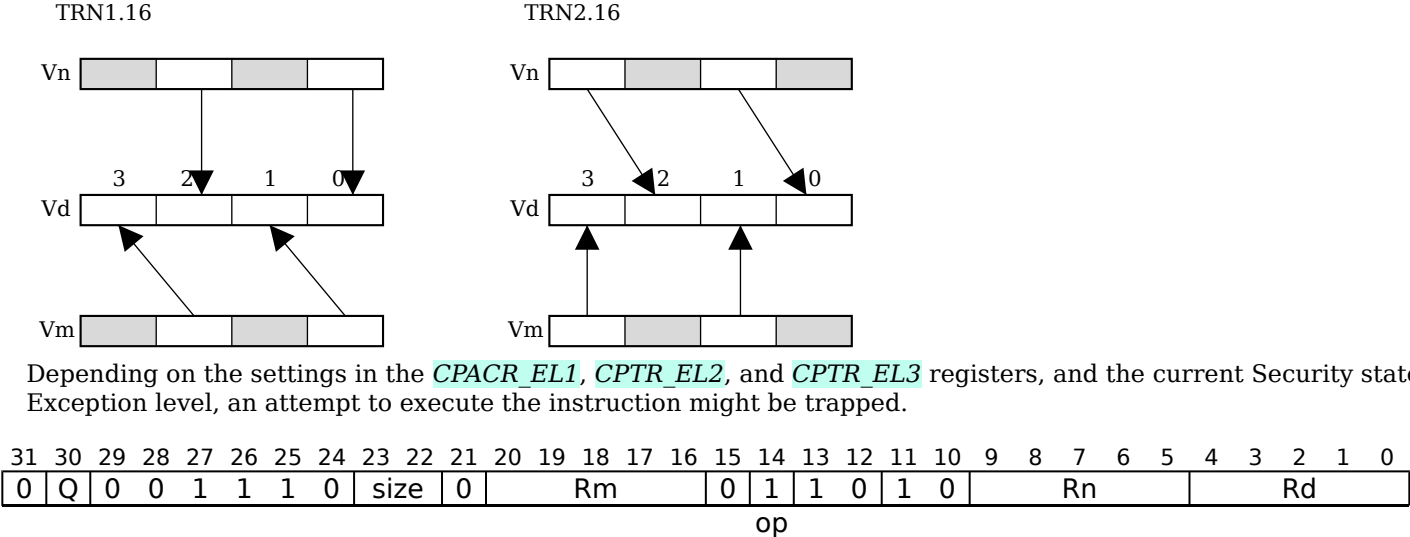
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

TRN2

Transpose vectors (secondary). This instruction reads corresponding odd-numbered vector elements from the two source SIMD&FP registers, places each result into consecutive elements of a vector, and writes the vector to the destination SIMD&FP register. Vector elements from the first source register are placed into even-numbered elements of the destination vector, starting at zero, while vector elements from the second source register are placed into odd-numbered elements of the destination vector.

By using this instruction with TRN1, a 2 x 2 matrix can be transposed.

The following figure shows an example of the operation of TRN1 and TRN2 halfword operations where Q = 0.



TRN2 <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
integer part = UInt(op);
integer pairs = elements DIV 2;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

for p = 0 to pairs-1
    Elem[result, 2*p+0, esize] = Elem[operand1, 2*p+part, esize];
    Elem[result, 2*p+1, esize] = Elem[operand2, 2*p+part, esize];

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

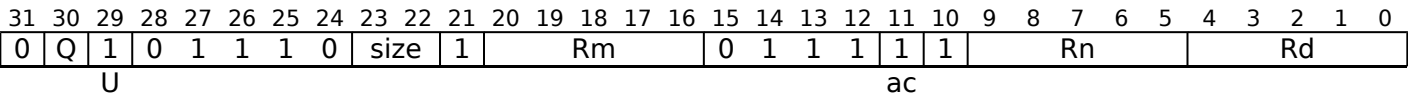
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UABA

Unsigned Absolute difference and Accumulate. This instruction subtracts the elements of the vector of the second source SIMD&FP register from the corresponding elements of the first source SIMD&FP register, and accumulates the absolute values of the results into the elements of the vector of the destination SIMD&FP register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



UABA <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean accumulate = (ac == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
bits(esize) absdiff;

result = if accumulate then V[d] else Zeros();
for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    absdiff = Abs(element1-element2)<esize-1:0>;
    Elem[result, e, esize] = Elem[result, e, esize] + absdiff;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

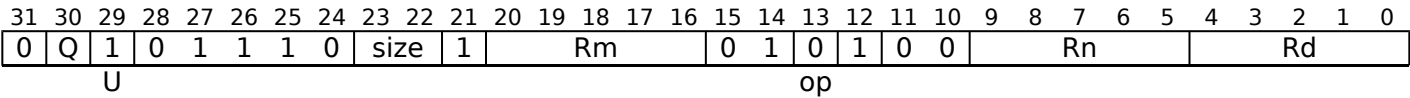
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UABAL, UABAL2

Unsigned Absolute difference and Accumulate Long. This instruction subtracts the vector elements in the lower or upper half of the second source SIMD&FP register from the corresponding vector elements of the first source SIMD&FP register, and accumulates the absolute values of the results into the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the source vector elements. All the values in this instruction are unsigned integer values.

The UABAL instruction extracts each source vector from the lower half of each source register, while the UABAL2 instruction extracts each source vector from the upper half of each source register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



UABAL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean accumulate = (op == '0');
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) absdiff;

result = if accumulate then V[d] else Zeros();
for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    absdiff = Abs(element1-element2)<2*esize-1:0>;
    Elem[result, e, 2*esize] = Elem[result, e, 2*esize] + absdiff;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

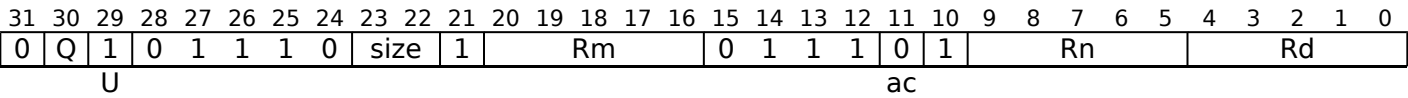
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UABD

Unsigned Absolute Difference (vector). This instruction subtracts the elements of the vector of the second source SIMD&FP register from the corresponding elements of the first source SIMD&FP register, places the the absolute values of the results into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



UABD <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean accumulate = (ac == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
bits(esize) absdiff;

result = if accumulate then V[d] else Zeros();
for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    absdiff = Abs(element1-element2)<esize-1:0>;
    Elem[result, e, esize] = Elem[result, e, esize] + absdiff;
V[d] = result;
```



## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

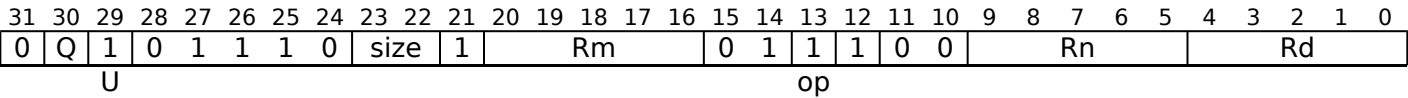
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UABDL, UABDL2

Unsigned Absolute Difference Long. This instruction subtracts the vector elements in the lower or upper half of the second source SIMD&FP register from the corresponding vector elements of the first source SIMD&FP register, places the absolute value of the result into a vector, and writes the vector to the destination SIMD&FP register. The destination vector elements are twice as long as the source vector elements. All the values in this instruction are unsigned integer values.

The UABDL instruction extracts each source vector from the lower half of each source register, while the UABDL2 instruction extracts each source vector from the upper half of each source register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



UABDL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean accumulate = (op == '0');
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) absdiff;

result = if accumulate then V[d] else Zeros();
for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    absdiff = Abs(element1-element2)<2*esize-1:0>;
    Elem[result, e, 2*esize] = Elem[result, e, 2*esize] + absdiff;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

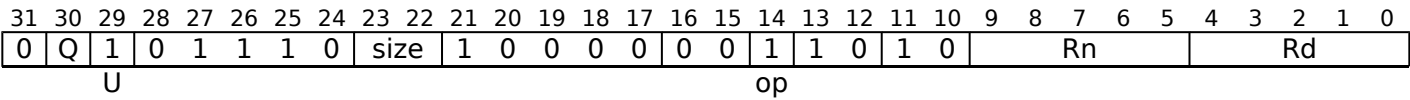
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UADALP

Unsigned Add and Accumulate Long Pairwise. This instruction adds pairs of adjacent unsigned integer values from the vector in the source SIMD&FP register and accumulates the results with the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the source vector elements.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



UADALP <Vd>.<Ta>, <Vn>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV (2 * esize);
boolean acc = (op == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in "size:Q":

size	Q	<Ta>
00	0	4H
00	1	8H
01	0	2S
01	1	4S
10	0	1D
10	1	2D
11	x	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in "size:Q":

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;

bits(2*esize) sum;
integer op1;
integer op2;

if acc then result = V[d];
for e = 0 to elements-1
    op1 = Int(Elem[operand, 2*e+0, esize], unsigned);
    op2 = Int(Elem[operand, 2*e+1, esize], unsigned);
    sum = (op1+op2)<2*esize-1:0>;
    if acc then
        Elem[result, e, 2*esize] = Elem[result, e, 2*esize] + sum;
    else
        Elem[result, e, 2*esize] = sum;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

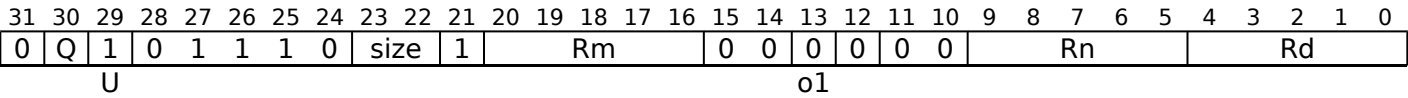
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UADDL, UADDL2

Unsigned Add Long (vector). This instruction adds each vector element in the lower or upper half of the first source SIMD&FP register to the corresponding vector element of the second source SIMD&FP register, places the result into a vector, and writes the vector to the destination SIMD&FP register. The destination vector elements are twice as long as the source vector elements. All the values in this instruction are unsigned integer values.

The UADDL instruction extracts each source vector from the lower half of each source register, while the UADDL2 instruction extracts each source vector from the upper half of each source register.

Depending on the settings in the CPACR EL1, CPTR EL2, and CPTR EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



UADDL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean sub_op = (o1 == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q 2	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
integer element1;
integer element2;
integer sum;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    if sub_op then
        sum = element1 - element2;
    else
        sum = element1 + element2;
    Elem[result, e, 2*esize] = sum<2*esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

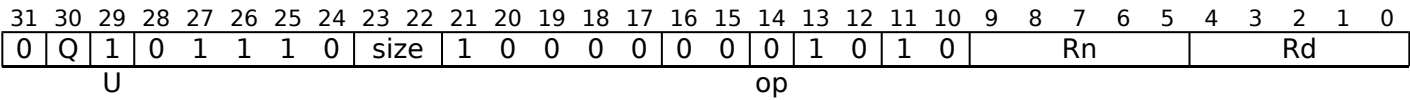
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UADDLP

Unsigned Add Long Pairwise. This instruction adds pairs of adjacent unsigned integer values from the vector in the source SIMD&FP register, places the result into a vector, and writes the vector to the destination SIMD&FP register. The destination vector elements are twice as long as the source vector elements.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



UADDLP <Vd>.<Ta>, <Vn>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV (2 * esize);
boolean acc = (op == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in "size:Q":

size	Q	<Ta>
00	0	4H
00	1	8H
01	0	2S
01	1	4S
10	0	1D
10	1	2D
11	x	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in "size:Q":

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED



## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;

bits(2*esize) sum;
integer op1;
integer op2;

if acc then result = V[d];
for e = 0 to elements-1
    op1 = Int(Elem[operand, 2*e+0, esize], unsigned);
    op2 = Int(Elem[operand, 2*e+1, esize], unsigned);
    sum = (op1+op2)<2*esize-1:0>;
    if acc then
        Elem[result, e, 2*esize] = Elem[result, e, 2*esize] + sum;
    else
        Elem[result, e, 2*esize] = sum;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

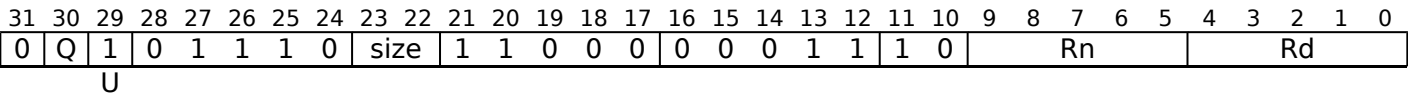
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UADDLV

Unsigned sum Long across Vector. This instruction adds every vector element in the source SIMD&FP register together, and writes the scalar result to the destination SIMD&FP register. The destination scalar is twice as long as the source vector elements. All the values in this instruction are unsigned integer values.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



UADDLV <V><d>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '100' then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
```

Assembler Symbols

<V> Is the destination width specifier, encoded in “size”:

size	<V>
00	H
01	S
10	D
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<T> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	RESERVED
10	1	4S
11	x	RESERVED

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
integer sum;

sum = Int(Elem[operand, 0, esize], unsigned);
for e = 1 to elements-1
    sum = sum + Int(Elem[operand, e, esize], unsigned);

V[d] = sum<2*esize-1:0>;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

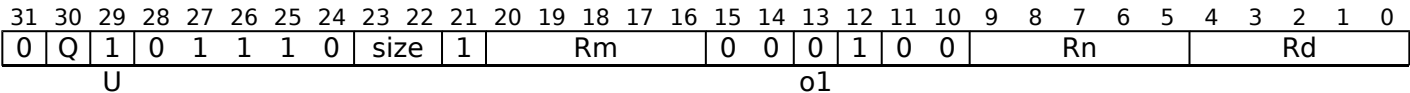
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UADDW, UADDW2

Unsigned Add Wide. This instruction adds the vector elements of the first source SIMD&FP register to the corresponding vector elements in the lower or upper half of the second source SIMD&FP register, places the result in a vector, and writes the vector to the SIMD&FP destination register. The vector elements of the destination register and the first source register are twice as long as the vector elements of the second source register. All the values in this instruction are unsigned integer values.

The UADDW instruction extracts vector elements from the lower half of the second source register, while the UADDW2 instruction extracts vector elements from the upper half of the second source register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



UADDW{2} <Vd>.<Ta>, <Vn>.<Ta>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean sub_op = (o1 == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(2*datasize) operand1 = V[n];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
integer element1;
integer element2;
integer sum;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, 2*esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    if sub_op then
        sum = element1 - element2;
    else
        sum = element1 + element2;
    Elem[result, e, 2*esize] = sum<2*esize-1:0>;

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## UCVTF (vector, fixed-point)

Unsigned fixed-point Convert to Floating-point (vector). This instruction converts each element in a vector from fixed-point to floating-point using the rounding mode that is specified by the [FPCR](#), and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	1	0	!= 0000				immb			1	1	1	0	0	1	Rn				Rd					
U									immb																						

UCVTF <V><d>, <V><n>, #<fbits>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '000x' || (immh == '001x' && !HaveFP16Ext()) then UNDEFINED;
integer esize = if immh == '1xxx' then 64 else if immh == '01xx' then 32 else 16;
integer datasize = esize;
integer elements = 1;

integer fracbits = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
FPRounding rounding = FPRoundingMode(FPCR[]);
```

### Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	0	!= 0000				immb			1	1	1	0	0	1	Rn				Rd					
U									immb																						

UCVTF <Vd>.<T>, <Vn>.<T>, #<fbits>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh == '000x' || (immh == '001x' && !HaveFP16Ext()) then UNDEFINED;
if immh<3>:Q == '10' then UNDEFINED;
integer esize = if immh == '1xxx' then 64 else if immh == '01xx' then 32 else 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer fracbits = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
FPRounding rounding = FPRoundingMode(FPCR[]);
```

### Assembler Symbols

<V> Is a width specifier, encoded in “immh”:

immh	<V>
000x	RESERVED
001x	H
01xx	S
1xxx	D

<d> Is the number of the SIMD&FP destination register, in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	x	RESERVED
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<fbits> For the scalar variant: is the number of fractional bits, in the range 1 to the operand width, encoded in "immh:immb":

immh	<fbits>
000x	RESERVED
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

For the vector variant: is the number of fractional bits, in the range 1 to the element width, encoded in "immh:immb":

immh	<fbits>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	RESERVED
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];

bits(esize) element;
FPCRTYPE fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[d] else Zeros();

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FixedToFP(element, fracbits, unsigned, fpcr, rounding);
V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# UCVTF (vector, integer)

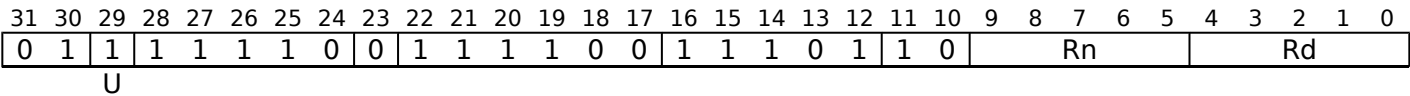
Unsigned integer Convert to Floating-point (vector). This instruction converts each element in a vector from an unsigned integer value to a floating-point value using the rounding mode that is specified by the *FPCR*, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (FEAT\_FP16)



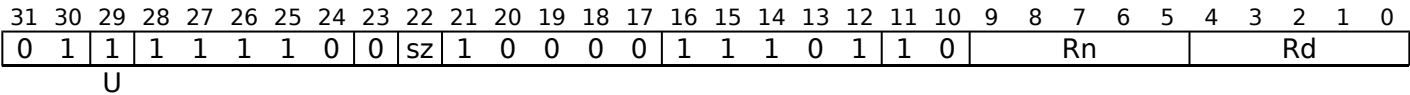
UCVTF <Hd>, <Hn>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
```

## Scalar single-precision and double-precision

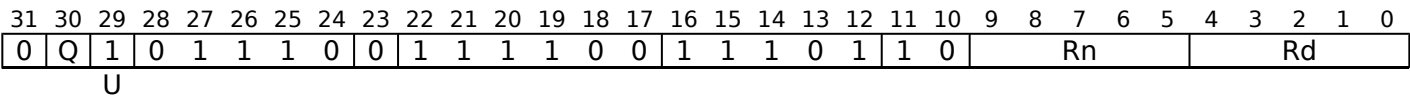


UCVTF <V><d>, <V><n>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
```

## Vector half precision (FEAT\_FP16)





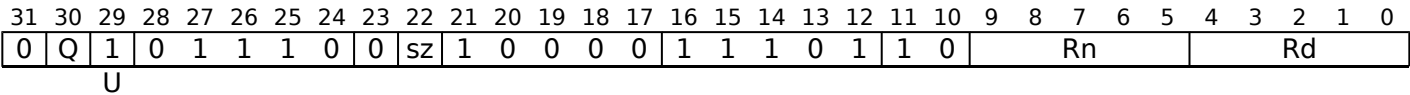
UCVTF <Vd>.<T>, <Vn>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
```

Vector single-precision and double-precision



UCVTF <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];

FPCRType fpcr = FPCR[];
boolean merge = elements == 1 && IsMerging(fpcr);
bits(128) result = if merge then V[d] else Zeros();

FPRounding rounding = FPRoundingMode(fpcr);
bits(esize) element;
for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FixedToFP(element, 0, unsigned, fpcr, rounding);

V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

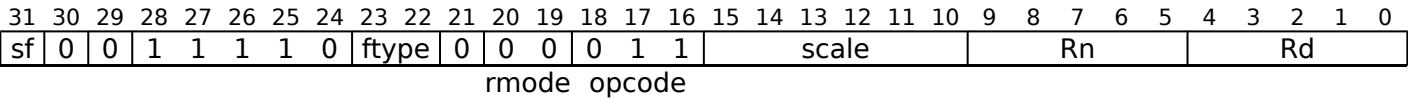
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UCVTF (scalar, fixed-point)

Unsigned fixed-point Convert to Floating-point (scalar). This instruction converts the unsigned value in the 32-bit or 64-bit general-purpose source register to a floating-point value using the rounding mode that is specified by the *FPCR*, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.



**32-bit to half-precision (sf == 0 && ftype == 11)**  
(FEAT\_FP16)

UCVTF <Hd>, <Wn>, #<fbits>

**32-bit to single-precision (sf == 0 && ftype == 00)**

UCVTF <Sd>, <Wn>, #<fbits>

**32-bit to double-precision (sf == 0 && ftype == 01)**

UCVTF <Dd>, <Wn>, #<fbits>

**64-bit to half-precision (sf == 1 && ftype == 11)**  
(FEAT\_FP16)

UCVTF <Hd>, <Xn>, #<fbits>

**64-bit to single-precision (sf == 1 && ftype == 00)**

UCVTF <Sd>, <Xn>, #<fbits>

**64-bit to double-precision (sf == 1 && ftype == 01)**

UCVTF <Dd>, <Xn>, #<fbits>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;
FPRounding rounding;

case ftype of
  when '00' fltsize = 32;
  when '01' fltsize = 64;
  when '10' UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;

if sf == '0' && scale<5> == '0' then UNDEFINED;
integer fracbits = 64 - UInt(scale);

rounding = FPRoundingMode(FPCR[]);
```

**Assembler Symbols**

<Dd>	Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Hd>	Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Sd>	Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
<fbits>	For the 32-bit to double-precision, 32-bit to half-precision and 32-bit to single-precision variant: is the number of bits after the binary point in the fixed-point source, in the range 1 to 32, encoded as 64 minus "scale".

For the 64-bit to double-precision, 64-bit to half-precision and 64-bit to single-precision variant: is the number of bits after the binary point in the fixed-point source, in the range 1 to 64, encoded as 64 minus "scale".

## Operation

```
CheckFPAdvSIMDEnabled64();

FPCRTYPE fpcr = FPCR[];
boolean merge = IsMerging(fpcr);
integer fsize = if merge then 128 else fltsize;
bits(fsize) fltval;
bits(intsize) intval;

intval = X[n];
fltval = if merge then V[d] else Zeros();
Elem[fltval, 0, fltsize] = FixedToFP(intval, fracbits, TRUE, fpcr, rounding);
V[d] = fltval;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

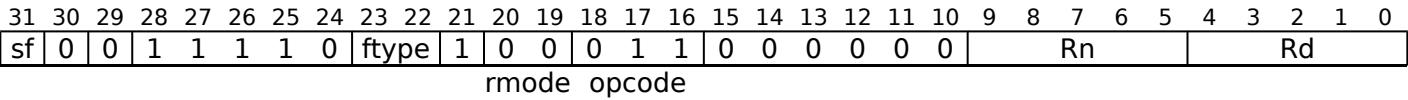
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UCVTF (scalar, integer)

Unsigned integer Convert to Floating-point (scalar). This instruction converts the unsigned integer value in the general-purpose source register to a floating-point value using the rounding mode that is specified by the *FPCR*, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



**32-bit to half-precision (sf == 0 && ftype == 11)**  
(FEAT\_FP16)

UCVTF <Hd>, <Wn>

**32-bit to single-precision (sf == 0 && ftype == 00)**

UCVTF <Sd>, <Wn>

**32-bit to double-precision (sf == 0 && ftype == 01)**

UCVTF <Dd>, <Wn>

**64-bit to half-precision (sf == 1 && ftype == 11)**  
(FEAT\_FP16)

UCVTF <Hd>, <Xn>

**64-bit to single-precision (sf == 1 && ftype == 00)**

UCVTF <Sd>, <Xn>

**64-bit to double-precision (sf == 1 && ftype == 01)**

UCVTF <Dd>, <Xn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;
FPRounding rounding;

case ftype of
  when '00'
    fltsize = 32;
  when '01'
    fltsize = 64;
  when '10'
    UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;

rounding = FPRoundingMode(FPCR[]);
```

**Assembler Symbols**

<Dd>	Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Hd>	Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Sd>	Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
FPCRTType fpcr = FPCR[];  
boolean merge = IsMerging(fpcr);  
integer fsize = if merge then 128 else fltsize;  
bits(fsize) fltval;  
bits(intsize) intval;  
  
intval = X[n];  
fltval = if merge then V[d] else Zeros();  
Elem[fltval, 0, fltsize] = FixedToFP(intval, 0, TRUE, fpcr, rounding);  
V[d] = fltval;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

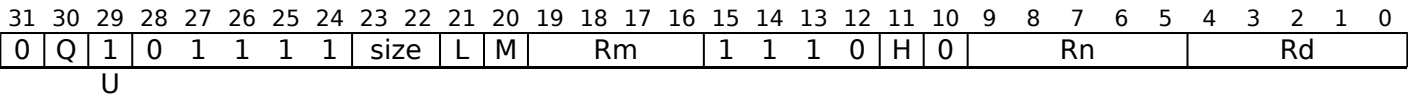
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



UDOT (by element)

Dot Product unsigned arithmetic (vector, by element). This instruction performs the dot product of the four 8-bit elements in each 32-bit element of the first source register with the four 8-bit elements of an indexed 32-bit element in the second source register, accumulating the result into the corresponding 32-bit element of the destination register. Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped. In Armv8.2 and Armv8.3, this is an OPTIONAL instruction. From Armv8.4 it is mandatory for all implementations to support it. ID\_AA64ISAR0\_EL1.DP indicates whether this instruction is supported.

Vector (FEAT\_DotProd)



UDOT <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.4B[<index>]

```
if !HaveDOTPExt() then UNDEFINED;
if size != '10' then UNDEFINED;
boolean signed = (U == '0');

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(M:Rm);
integer index = UInt(H:L);

integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

- <Vd>

Is the name of the SIMD&FP third source and destination register, encoded in the "Rd" field.
- <Ta>

Is an arrangement specifier, encoded in "Q":

Q	<Ta>
0	2S
1	4S
- <Vn>

Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Tb>

Is an arrangement specifier, encoded in "Q":

Q	<Tb>
0	8B
1	16B
- <Vm>

Is the name of the second SIMD&FP source register, encoded in the "M:Rm" fields.
- <index>

Is the element index, encoded in the "H:L" fields.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(128) operand2 = V[m];
bits(datasize) result = V[d];
for e = 0 to elements-1
    integer res = 0;
    integer element1, element2;
    for i = 0 to 3
        if signed then
            element1 = SInt(Elem[operand1, 4*e+i, esize DIV 4]);
            element2 = SInt(Elem[operand2, 4*index+i, esize DIV 4]);
        else
            element1 = UInt(Elem[operand1, 4*e+i, esize DIV 4]);
            element2 = UInt(Elem[operand2, 4*index+i, esize DIV 4]);
        res = res + element1 * element2;
    Elem[result, e, esize] = Elem[result, e, esize] + res;
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UDOT (vector)

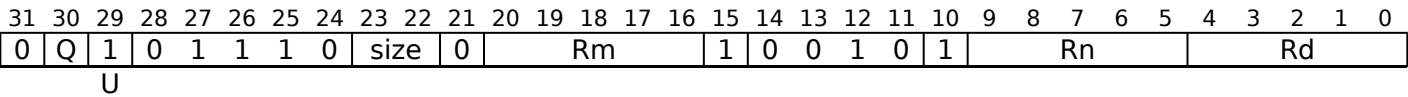
Dot Product unsigned arithmetic (vector). This instruction performs the dot product of the four unsigned 8-bit elements in each 32-bit element of the first source register with the four unsigned 8-bit elements of the corresponding 32-bit element in the second source register, accumulating the result into the corresponding 32-bit element of the destination register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

In Armv8.2 and Armv8.3, this is an OPTIONAL instruction. From Armv8.4 it is mandatory for all implementations to support it.

ID\_AA64ISAR0\_EL1.DP indicates whether this instruction is supported.

Vector  
(FEAT\_DotProd)



UDOT <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
if !HaveD0TPExt() then UNDEFINED;
if size != '10' then UNDEFINED;
boolean signed = (U == '0');
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP third source and destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in "Q":

Q	<Ta>
0	2S
1	4S

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in "Q":

Q	<Tb>
0	8B
1	16B

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

result = V[d];
for e = 0 to elements-1
    integer res = 0;
    integer element1, element2;
    for i = 0 to 3
        if signed then
            element1 = SInt(Elem[operand1, 4*e+i, esize DIV 4]);
            element2 = SInt(Elem[operand2, 4*e+i, esize DIV 4]);
        else
            element1 = UInt(Elem[operand1, 4*e+i, esize DIV 4]);
            element2 = UInt(Elem[operand2, 4*e+i, esize DIV 4]);
        res = res + element1 * element2;
    Elem[result, e, esize] = Elem[result, e, esize] + res;
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

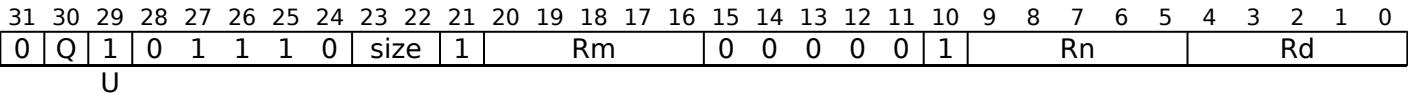
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UHADD

Unsigned Halving Add. This instruction adds corresponding unsigned integer values from the two source SIMD&FP registers, shifts each result right one bit, places the results into a vector, and writes the vector to the destination SIMD&FP register.

The results are truncated. For rounded results, see [URHADD](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



UHADD <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
integer sum;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    sum = element1 + element2;
    Elem[result, e, esize] = sum<esize:1>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

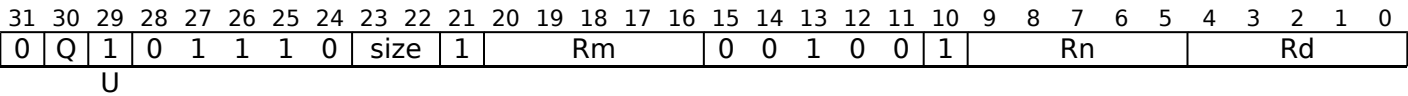
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UHSUB

Unsigned Halving Subtract. This instruction subtracts the vector elements in the second source SIMD&FP register from the corresponding vector elements in the first source SIMD&FP register, shifts each result right one bit, places each result into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



UHSUB <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
integer diff;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    diff = element1 - element2;
    Elem[result, e, esize] = diff<esize:1>;

V[d] = result;
```

Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

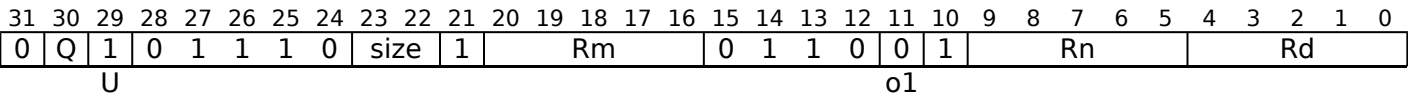
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



UMAX

Unsigned Maximum (vector). This instruction compares corresponding elements in the vectors in the two source SIMD&FP registers, places the larger of each pair of unsigned integer values into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



UMAX <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean minimum = (o1 == '1');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
integer maxmin;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    maxmin = if minimum then Min(element1, element2) else Max(element1, element2);
    Elem[result, e, esize] = maxmin<esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

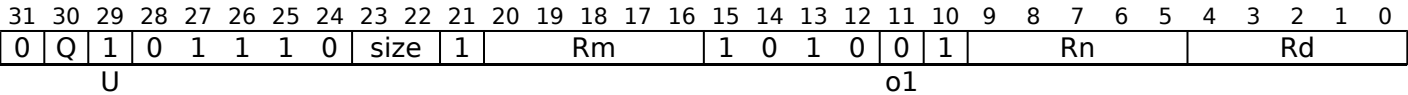
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UMAXP

Unsigned Maximum Pairwise. This instruction creates a vector by concatenating the vector elements of the first source SIMD&FP register after the vector elements of the second source SIMD&FP register, reads each pair of adjacent vector elements in the two source SIMD&FP registers, writes the largest of each pair of unsigned integer values into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



UMAXP <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean minimum = (o1 == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(2*datasize) concat = operand2:operand1;
integer element1;
integer element2;
integer maxmin;

for e = 0 to elements-1
    element1 = Int(Elem[concat, 2*e, esize], unsigned);
    element2 = Int(Elem[concat, (2*e)+1, esize], unsigned);
    maxmin = if minimum then Min(element1, element2) else Max(element1, element2);
    Elem[result, e, esize] = maxmin<esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

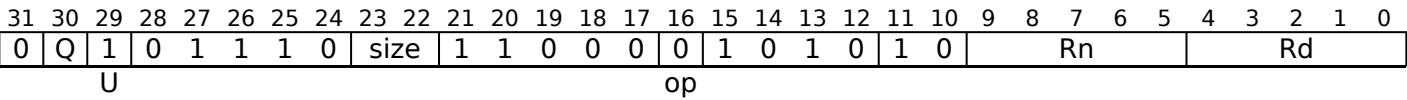
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UMAXV

Unsigned Maximum across Vector. This instruction compares all the vector elements in the source SIMD&FP register, and writes the largest of the values as a scalar to the destination SIMD&FP register. All the values in this instruction are unsigned integer values.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



UMAXV <V><d>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '100' then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean min = (op == '1');
```

Assembler Symbols

<V> Is the destination width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<T> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	RESERVED
10	1	4S
11	x	RESERVED

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
integer maxmin;
integer element;

maxmin = Int(Elem[operand, 0, esize], unsigned);
for e = 1 to elements-1
    element = Int(Elem[operand, e, esize], unsigned);
    maxmin = if min then Min(maxmin, element) else Max(maxmin, element);

V[d] = maxmin<esize-1:0>;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

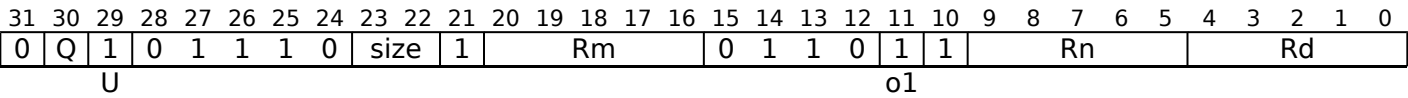
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UMIN

Unsigned Minimum (vector). This instruction compares corresponding vector elements in the two source SIMD&FP registers, places the smaller of each of the two unsigned integer values into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



UMIN <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean minimum = (o1 == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
integer maxmin;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    maxmin = if minimum then Min(element1, element2) else Max(element1, element2);
    Elem[result, e, esize] = maxmin<esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

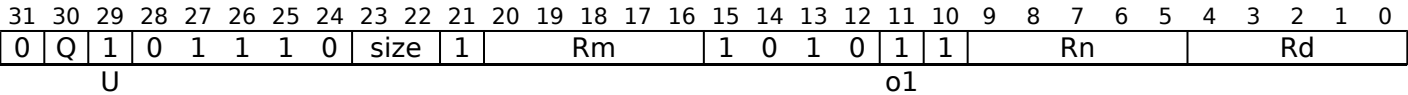
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



UMINP

Unsigned Minimum Pairwise. This instruction creates a vector by concatenating the vector elements of the first source SIMD&FP register after the vector elements of the second source SIMD&FP register, reads each pair of adjacent vector elements in the two source SIMD&FP registers, writes the smallest of each pair of unsigned integer values into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



UMINP <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean minimum = (o1 == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(2*datasize) concat = operand2:operand1;
integer element1;
integer element2;
integer maxmin;

for e = 0 to elements-1
    element1 = Int(Elem[concat, 2*e, esize], unsigned);
    element2 = Int(Elem[concat, (2*e)+1, esize], unsigned);
    maxmin = if minimum then Min(element1, element2) else Max(element1, element2);
    Elem[result, e, esize] = maxmin<esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

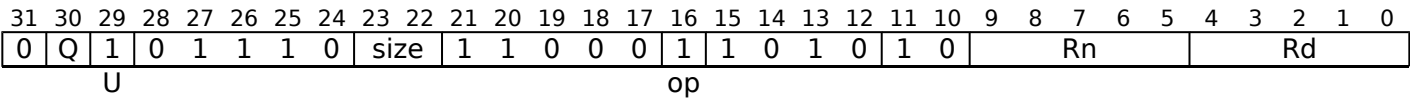
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UMINV

Unsigned Minimum across Vector. This instruction compares all the vector elements in the source SIMD&FP register, and writes the smallest of the values as a scalar to the destination SIMD&FP register. All the values in this instruction are unsigned integer values.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



UMINV <V><d>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '100' then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean min = (op == '1');
```

Assembler Symbols

<V> Is the destination width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<T> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	RESERVED
10	1	4S
11	x	RESERVED

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
integer maxmin;
integer element;

maxmin = Int(Elem[operand, 0, esize], unsigned);
for e = 1 to elements-1
    element = Int(Elem[operand, e, esize], unsigned);
    maxmin = if min then Min(maxmin, element) else Max(maxmin, element);

V[d] = maxmin<esize-1:0>;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

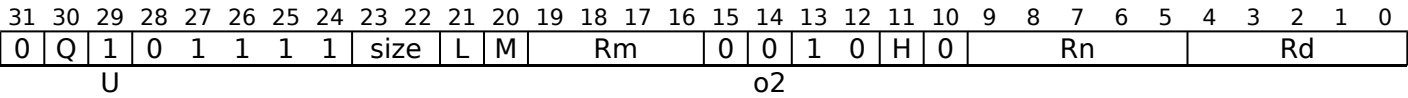
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UMLAL, UMLAL2 (by element)

Unsigned Multiply-Add Long (vector, by element). This instruction multiplies each vector element in the lower or upper half of the first source SIMD&FP register by the specified vector element of the second source SIMD&FP register and accumulates the results with the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied.

The UMLAL instruction extracts vector elements from the lower half of the first source register, while the UMLAL2 instruction extracts vector elements from the upper half of the first source register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



UMLAL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Ts>[<index>]

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean sub_op = (o2 == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	RESERVED
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in “size:M:Rm”:

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

Restricted to V0-V15 when element size <Ts> is H.

<Ts> Is an element size specifier, encoded in “size”:

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in “size:L:H:M”:

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(idxsizesize) operand2 = V[m];
bits(2*datasize) operand3 = V[d];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;

element2 = Int(Elem[operand2, index, esize], unsigned);
for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    product = (element1*element2)<2*esize-1:0>;
    if sub_op then
        Elem[result, e, 2*esize] = Elem[operand3, e, 2*esize] - product;
    else
        Elem[result, e, 2*esize] = Elem[operand3, e, 2*esize] + product;
V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

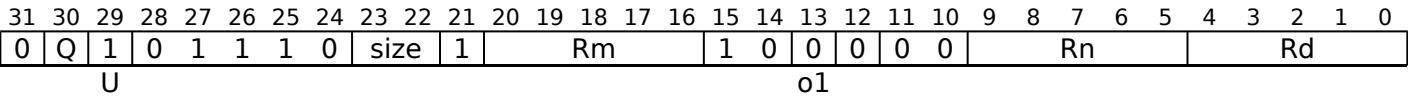


UMLAL, UMLAL2 (vector)

Unsigned Multiply-Add Long (vector). This instruction multiplies the vector elements in the lower or upper half of the first source SIMD&FP register by the corresponding vector elements of the second source SIMD&FP register, and accumulates the results with the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied.

The UMLAL instruction extracts vector elements from the lower half of the first source register, while the UMLAL2 instruction extracts vector elements from the upper half of the first source register.

Depending on the settings in the CPACR EL1, CPTR EL2, and CPTR EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



UMLAL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;
boolean sub_op = (o1 == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q 2	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.



## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) operand3 = V[d];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;
bits(2*esize) accum;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    product = (element1*element2)<2*esize-1:0>;
    if sub_op then
        accum = Elem[operand3, e, 2*esize] - product;
    else
        accum = Elem[operand3, e, 2*esize] + product;
    Elem[result, e, 2*esize] = accum;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

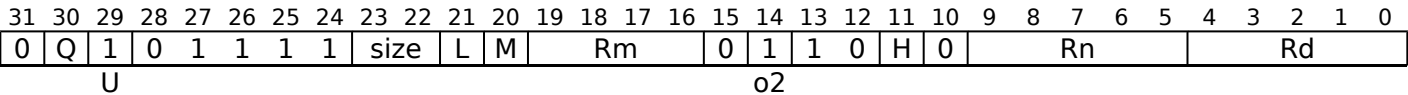
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UMLSL, UMLSL2 (by element)

Unsigned Multiply-Subtract Long (vector, by element). This instruction multiplies each vector element in the lower or upper half of the first source SIMD&FP register by the specified vector element of the second source SIMD&FP register and subtracts the results from the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied.

The UMLSL instruction extracts vector elements from the lower half of the first source register, while the UMLSL2 instruction extracts vector elements from the upper half of the first source register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



UMLSL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Ts>[<index>]

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean sub_op = (o2 == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q 2	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	RESERVED
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in “size:M:Rm”:

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

Restricted to V0-V15 when element size <Ts> is H.

<Ts> Is an element size specifier, encoded in “size”:

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in “size:L:H:M”:

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(idxsizesize) operand2 = V[m];
bits(2*datasize) operand3 = V[d];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;

element2 = Int(Elem[operand2, index, esize], unsigned);
for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    product = (element1*element2)<2*esize-1:0>;
    if sub_op then
        Elem[result, e, 2*esize] = Elem[operand3, e, 2*esize] - product;
    else
        Elem[result, e, 2*esize] = Elem[operand3, e, 2*esize] + product;
V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

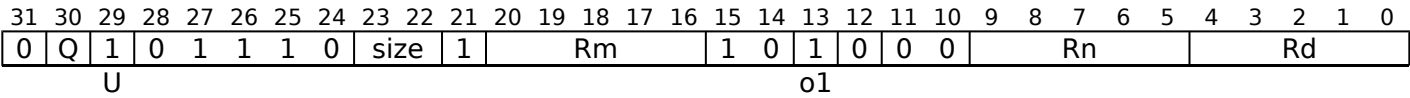


UMLSL, UMLSL2 (vector)

Unsigned Multiply-Subtract Long (vector). This instruction multiplies corresponding vector elements in the lower or upper half of the two source SIMD&FP registers, and subtracts the results from the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied. All the values in this instruction are unsigned integer values.

The UMLSL instruction extracts each source vector from the lower half of each source register, while the UMLSL2 instruction extracts each source vector from the upper half of each source register.

Depending on the settings in the CPACR EL1, CPTR EL2, and CPTR EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



UMLSL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;
boolean sub_op = (o1 == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q 2	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) operand3 = V[d];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;
bits(2*esize) accum;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    product = (element1*element2)<2*esize-1:0>;
    if sub_op then
        accum = Elem[operand3, e, 2*esize] - product;
    else
        accum = Elem[operand3, e, 2*esize] + product;
    Elem[result, e, 2*esize] = accum;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

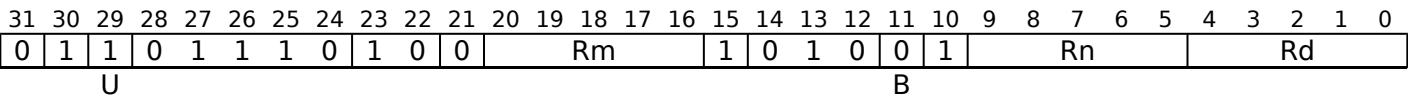
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# UMMLA (vector)

Unsigned 8-bit integer matrix multiply-accumulate. This instruction multiplies the 2x8 matrix of unsigned 8-bit integer values in the first source vector by the 8x2 matrix of unsigned 8-bit integer values in the second source vector. The resulting 2x2 32-bit integer matrix product is destructively added to the 32-bit integer matrix accumulator in the destination vector. This is equivalent to performing an 8-way dot product per destination element.

From Armv8.2 to Armv8.5, this is an OPTIONAL instruction. From Armv8.6 it is mandatory for implementations that include Advanced SIMD to support it. [ID\\_AA64ISAR1\\_EL1](#).I8MM indicates whether this instruction is supported.

## Vector (FEAT\_I8MM)



UMMLA <Vd>.4S, <Vn>.16B, <Vm>.16B

```
if !HaveInt8MatMulExt() then UNDEFINED;
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Rd);
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP third source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(128) operand1 = V[n];
bits(128) operand2 = V[m];
bits(128) addend = V[d];

V[d] = MatMulAdd(addend, operand1, operand2, TRUE, TRUE);
```

UMOV

Unsigned Move vector element to general-purpose register. This instruction reads the unsigned integer from the source SIMD&FP register, zero-extends it to form a 32-bit or 64-bit value, and writes the result to the destination general-purpose register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This instruction is used by the alias [MOV \(to general\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	0	0	imm5					0	0	1	1	1	1	Rn					Rd				

32-bit (Q == 0)

```
UMOV <Wd>, <Vn>.<Ts>[<index>]
```

64-reg,UMOV-64-reg (Q == 1 && imm5 == x1000)

```
UMOV <Xd>, <Vn>.<Ts>[<index>]
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer size;
case Q:imm5 of
    when '0xxxx1' size = 0;    // UMOV Wd, Vn.B
    when '0xxx10' size = 1;    // UMOV Wd, Vn.H
    when '0xx100' size = 2;    // UMOV Wd, Vn.S
    when '1x1000' size = 3;    // UMOV Xd, Vn.D
    otherwise UNDEFINED;

integer idxdsize = if imm5<4> == '1' then 128 else 64;
integer index = UInt(imm5<4:size+1>);
integer esize = 8 << size;
integer datasize = if Q == '1' then 64 else 32;
```

Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.
- <Ts> For the 32-bit variant: is an element size specifier, encoded in "imm5":

imm5	<Ts>
xx000	RESERVED
xxxx1	B
xxx10	H
xx100	S

For the 64-reg,UMOV-64-reg variant: is an element size specifier, encoded in "imm5":

imm5	<Ts>
x0000	RESERVED
xxxx1	RESERVED
xxx10	RESERVED
xx100	RESERVED
x1000	D



<index> For the 32-bit variant: is the element index encoded in “imm5”:

imm5	<index>
xx000	RESERVED
xxxx1	imm5<4:1>
xxx10	imm5<4:2>
xx100	imm5<4:3>

For the 64-reg,UMOV-64-reg variant: is the element index encoded in "imm5<4>".

Alias Conditions

Alias	Is preferred when
<a href="#">MOV (to general)</a>	imm5 == 'x1000'
<a href="#">MOV (to general)</a>	imm5 == 'xx100'

Operation

```
CheckFPAdvSIMDEnabled64();
bits(idxdsize) operand = V[n];

X[d] = ZeroExtend(Elem[operand, index, esize], datasize);
```

Operational information

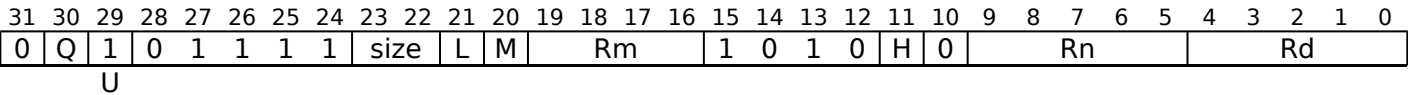
- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

UMULL, UMULL2 (by element)

Unsigned Multiply Long (vector, by element). This instruction multiplies each vector element in the lower or upper half of the first source SIMD&FP register by the specified vector element of the second source SIMD&FP register, places the results in a vector, and writes the vector to the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied.

The UMULL instruction extracts vector elements from the lower half of the first source register, while the UMULL2 instruction extracts vector elements from the upper half of the first source register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



UMULL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Ts>[<index>]

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q 2	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	RESERVED
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in “size:M:Rm”:

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

Restricted to V0-V15 when element size <Ts> is H.

<Ts> Is an element size specifier, encoded in “size”:

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in “size:L:H:M”:

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(idxsizesize) operand2 = V[m];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;

element2 = Int(Elem[operand2, index, esize], unsigned);
for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    product = (element1*element2)<2*esize-1:0>;
    Elem[result, e, 2*esize] = product;

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

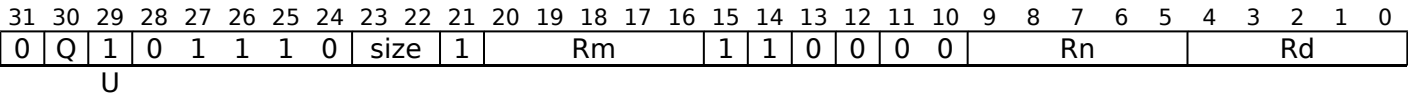
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UMULL, UMULL2 (vector)

Unsigned Multiply long (vector). This instruction multiplies corresponding vector elements in the lower or upper half of the two source SIMD&FP registers, places the result in a vector, and writes the vector to the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied. All the values in this instruction are unsigned integer values.

The UMULL instruction extracts each source vector from the lower half of each source register, while the UMULL2 instruction extracts each source vector from the upper half of each source register.

Depending on the settings in the CPACR EL1, CPTR EL2, and CPTR EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



UMULL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q2	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
integer element1;
integer element2;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    Elem[result, e, 2*esize] = (element1*element2)<2*esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

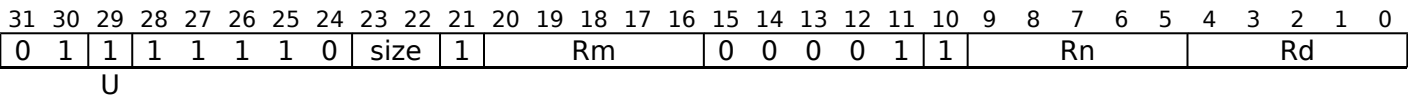
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UQADD

Unsigned saturating Add. This instruction adds the values of corresponding elements of the two source SIMD&FP registers, places the results into a vector, and writes the vector to the destination SIMD&FP register. If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit *FPSR.QC* is set. Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

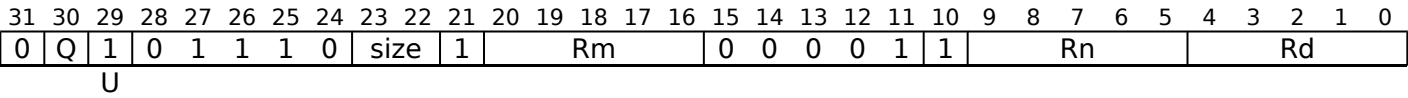
Scalar



UQADD <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
```

Vector



UQADD <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
integer sum;
boolean sat;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    sum = element1 + element2;
    (Elem[result, e, esize], sat) = SatQ(sum, esize, unsigned);
    if sat then FPSR.QC = '1';

V[d] = result;
```

# UQRSHL

Unsigned saturating Rounding Shift Left (register). This instruction takes each vector element of the first source SIMD&FP register, shifts the vector element by a value from the least significant byte of the corresponding vector element of the second source SIMD&FP register, places the results into a vector, and writes the vector to the destination SIMD&FP register.

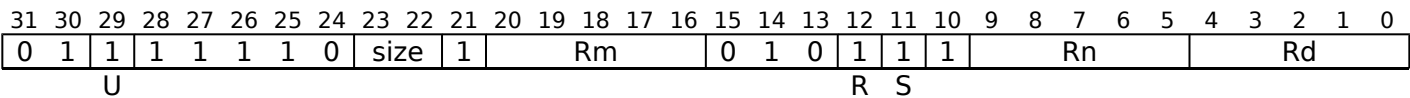
If the shift value is positive, the operation is a left shift. Otherwise, it is a right shift. The results are rounded. For truncated results, see [UQSHL](#).

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

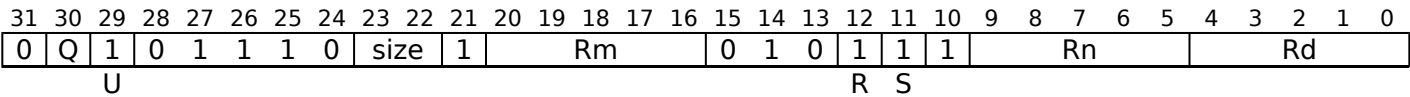
## Scalar



UQRSHL <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
if S == '0' && size != '11' then UNDEFINED;
```

## Vector



UQRSHL <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
```

## Assembler Symbols

<V> Is a width specifier, encoded in “size”:



size	<V>
00	B
01	H
10	S
11	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

integer round_const = 0;
integer shift;
integer element;
boolean sat;

for e = 0 to elements-1
    shift = SInt(Elem[operand2, e, esize]<7:0>);
    if rounding then
        round_const = 1 << (-shift - 1);    // 0 for left shift, 2^(n-1) for right shift
    element = (Int(Elem[operand1, e, esize], unsigned) + round_const) << shift;
    if saturating then
        (Elem[result, e, esize], sat) = SatQ(element, esize, unsigned);
        if sat then FPSR.QC = '1';
    else
        Elem[result, e, esize] = element<esize-1:0>;

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## UQRSHRN, UQRSHRN2

Unsigned saturating Rounded Shift Right Narrow (immediate). This instruction reads each vector element in the source SIMD&FP register, right shifts each result by an immediate value, puts the final result into a vector, and writes the vector to the lower or upper half of the destination SIMD&FP register. All the values in this instruction are unsigned integer values. The results are rounded. For truncated results, see [UQSHRN](#).

The UQRSHRN instruction writes the vector to the lower half of the destination register and clears the upper half, while the UQRSHRN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	1	0	!= 0000				immb			1	0	0	1	1	1	Rn				Rd					
U									immh				op																		

**UQRSHRN** <Vb><d>, <Va><n>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then UNDEFINED;
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = esize;
integer elements = 1;
integer part = 0;

integer shift = (2 * esize) - UInt(immh:immb);
boolean round = (op == '1');
boolean unsigned = (U == '1');
```

### Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	0	!= 0000				immb			1	0	0	1	1	1	Rn				Rd					
U									immh				op																		

**UQRSHRN{2}** <Vd>.<Tb>, <Vn>.<Ta>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

integer shift = (2 * esize) - UInt(immh:immb);
boolean round = (op == '1');
boolean unsigned = (U == '1');
```

## Assembler Symbols

- 2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in "Q":

Q	2
0	[absent]
1	[present]

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

- <Tb> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<Tb>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	x	RESERVED

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

- <Ta> Is an arrangement specifier, encoded in "immh":

immh	<Ta>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	8H
001x	4S
01xx	2D
1xxx	RESERVED

- <Vb> Is the destination width specifier, encoded in "immh":

immh	<Vb>
0000	RESERVED
0001	B
001x	H
01xx	S
1xxx	RESERVED

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.

- <Va> Is the source width specifier, encoded in "immh":

immh	<Va>
0000	RESERVED
0001	H
001x	S
01xx	D
1xxx	RESERVED

- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

- <shift> For the scalar variant: is the right shift amount, in the range 1 to the destination operand width in bits, encoded in "immh:immb":

immh	<shift>
0000	RESERVED
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	RESERVED

For the vector variant: is the right shift amount, in the range 1 to the destination element width in bits, encoded in “immh:immb”:

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize*2) operand = V[n];
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;
boolean sat;

for e = 0 to elements-1
    element = (Int(Elem[operand, e, 2*esize], unsigned) + round_const) >> shift;
    (Elem[result, e, esize], sat) = SatQ(element, esize, unsigned);
    if sat then FPSR.QC = '1';

Vpart[d, part] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# UQSHL (immediate)

Unsigned saturating Shift Left (immediate). This instruction takes each vector element in the source SIMD&FP register, shifts it by an immediate value, places the results in a vector, and writes the vector to the destination SIMD&FP register. The results are truncated. For rounded results, see [UQRSHL](#).  
If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.  
Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	1	0	!= 0000				immb			0	1	1	1	0	1	Rn				Rd					
U									immh				op																		

UQSHL <V><d>, <V><n>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = esize;
integer elements = 1;

integer shift = UInt(immh:immb) - esize;

boolean src_unsigned;
boolean dst_unsigned;
case op:U of
    when '00' UNDEFINED;
    when '01' src_unsigned = FALSE; dst_unsigned = TRUE;
    when '10' src_unsigned = FALSE; dst_unsigned = FALSE;
    when '11' src_unsigned = TRUE; dst_unsigned = TRUE;
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	0	!= 0000				immb			0	1	1	1	0	1	Rn				Rd					
U									immh				op																		

UQSHL <Vd>.<T>, <Vn>.<T>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3>:Q == '10' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer shift = UInt(immh:immb) - esize;

boolean src_unsigned;
boolean dst_unsigned;
case op:U of
  when '00' UNDEFINED;
  when '01' src_unsigned = FALSE; dst_unsigned = TRUE;
  when '10' src_unsigned = FALSE; dst_unsigned = FALSE;
  when '11' src_unsigned = TRUE; dst_unsigned = TRUE;
```

## Assembler Symbols

<V> Is a width specifier, encoded in “immh”:

immh	<V>
0000	RESERVED
0001	B
001x	H
01xx	S
1xxx	D

<d> Is the number of the SIMD&FP destination register, in the “Rd” field.

<n> Is the number of the first SIMD&FP source register, encoded in the “Rn” field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the “Rd” field.

<T> Is an arrangement specifier, encoded in “immh:Q”:

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the “Rn” field.

<shift> For the scalar variant: is the left shift amount, in the range 0 to the operand width in bits minus 1, encoded in “immh:immb”:

immh	<shift>
0000	RESERVED
0001	(UInt(immh:immb)-8)
001x	(UInt(immh:immb)-16)
01xx	(UInt(immh:immb)-32)
1xxx	(UInt(immh:immb)-64)

For the vector variant: is the left shift amount, in the range 0 to the element width in bits minus 1, encoded in “immh:immb”:

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(UInt(immh:immb)-8)
001x	(UInt(immh:immb)-16)
01xx	(UInt(immh:immb)-32)
1xxx	(UInt(immh:immb)-64)

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
integer element;
boolean sat;

for e = 0 to elements-1
    element = Int(Elem[operand, e, esize], src_unsigned) << shift;
    (Elem[result, e, esize], sat) = SatQ(element, esize, dst_unsigned);
    if sat then FPSR.QC = '1';

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## UQSHL (register)

Unsigned saturating Shift Left (register). This instruction takes each element in the vector of the first source SIMD&FP register, shifts the element by a value from the least significant byte of the corresponding element of the second source SIMD&FP register, places the results in a vector, and writes the vector to the destination SIMD&FP register.

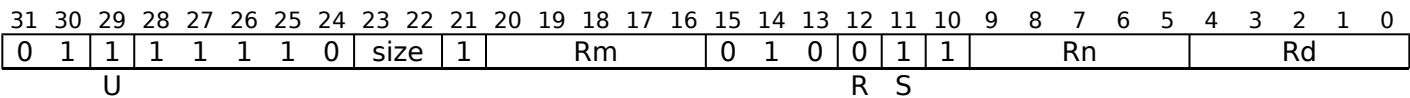
If the shift value is positive, the operation is a left shift. Otherwise, it is a right shift. The results are truncated. For rounded results, see [UQRSHL](#).

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

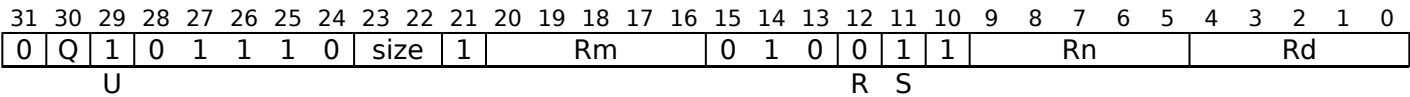
### Scalar



UQSHL <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
if S == '0' && size != '11' then UNDEFINED;
```

### Vector



UQSHL <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
```

### Assembler Symbols

<V> Is a width specifier, encoded in “size”:



size	<V>
00	B
01	H
10	S
11	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

integer round_const = 0;
integer shift;
integer element;
boolean sat;

for e = 0 to elements-1
    shift = SInt(Elem[operand2, e, esize]<7:0>);
    if rounding then
        round_const = 1 << (-shift - 1);    // 0 for left shift, 2^(n-1) for right shift
    element = (Int(Elem[operand1, e, esize], unsigned) + round_const) << shift;
    if saturating then
        (Elem[result, e, esize], sat) = SatQ(element, esize, unsigned);
        if sat then FPSR.QC = '1';
    else
        Elem[result, e, esize] = element<esize-1:0>;

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## UQSHRN, UQSHRN2

Unsigned saturating Shift Right Narrow (immediate). This instruction reads each vector element in the source SIMD&FP register, right shifts each result by an immediate value, saturates each shifted result to a value that is half the original width, puts the final result into a vector, and writes the vector to the lower or upper half of the destination SIMD&FP register. All the values in this instruction are unsigned integer values. The results are truncated. For rounded results, see [UQSRSHRN](#).

The UQSHRN instruction writes the vector to the lower half of the destination register and clears the upper half, while the UQSHRN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	!= 0000			immb			1	0	0	1	0	1	Rn					Rd						
U									immh						op																

**UQSHRN** [<Vb><d>](#), [<Va><n>](#), [#<shift>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then UNDEFINED;
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = esize;
integer elements = 1;
integer part = 0;

integer shift = (2 * esize) - UInt(immh:immb);
boolean round = (op == '1');
boolean unsigned = (U == '1');
```

### Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	0	!= 0000				immb			1	0	0	1	0	1	Rn					Rd				
U									immh						op																

**UQSHRN{2}** [<Vd>.<Tb>](#), [<Vn>.<Ta>](#), [#<shift>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

integer shift = (2 * esize) - UInt(immh:immb);
boolean round = (op == '1');
boolean unsigned = (U == '1');
```

## Assembler Symbols

- 2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in "Q":

Q	2
0	[absent]
1	[present]

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

- <Tb> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<Tb>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	x	RESERVED

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

- <Ta> Is an arrangement specifier, encoded in "immh":

immh	<Ta>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	8H
001x	4S
01xx	2D
1xxx	RESERVED

- <Vb> Is the destination width specifier, encoded in "immh":

immh	<Vb>
0000	RESERVED
0001	B
001x	H
01xx	S
1xxx	RESERVED

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.

- <Va> Is the source width specifier, encoded in "immh":

immh	<Va>
0000	RESERVED
0001	H
001x	S
01xx	D
1xxx	RESERVED

- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

- <shift> For the scalar variant: is the right shift amount, in the range 1 to the destination operand width in bits, encoded in "immh:immb":

immh	<shift>
0000	RESERVED
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	RESERVED

For the vector variant: is the right shift amount, in the range 1 to the destination element width in bits, encoded in “immh:immb”:

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize*2) operand = V[n];
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;
boolean sat;

for e = 0 to elements-1
    element = (Int(Elem[operand, e, 2*esize], unsigned) + round_const) >> shift;
    (Elem[result, e, esize], sat) = SatQ(element, esize, unsigned);
    if sat then FPSR.QC = '1';

Vpart[d, part] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UQSUB

Unsigned saturating Subtract. This instruction subtracts the element values of the second source SIMD&FP register from the corresponding element values of the first source SIMD&FP register, places the results into a vector, and writes the vector to the destination SIMD&FP register.

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit *FPSR.QC* is set.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	size	1	Rm						0	0	1	0	1	1	Rn						Rd			
U																															

UQSUB <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
```

Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	size	1	Rm						0	0	1	0	1	1	Rn						Rd			
U																															

UQSUB <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
integer diff;
boolean sat;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    diff = element1 - element2;
    (Elem[result, e, esize], sat) = SatQ(diff, esize, unsigned);
    if sat then FPSR.QC = '1';

V[d] = result;
```

# UQXTN, UQXTN2

Unsigned saturating extract Narrow. This instruction reads each vector element from the source SIMD&FP register, saturates each value to half the original width, places the result into a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are unsigned integer values.

If saturation occurs, the cumulative saturation bit *FPSR.QC* is set.

The UQXTN instruction writes the vector to the lower half of the destination register and clears the upper half, while the UQXTN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	size	1	0	0	0	0	1	0	1	0	0	1	0	Rn				Rd						
U																															

UQXTN <Vb><d>, <Va><n>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer part = 0;
integer elements = 1;

boolean unsigned = (U == '1');
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	size	1	0	0	0	0	1	0	1	0	0	1	0	Rn				Rd						
U																															

UQXTN{2} <Vd>.<Tb>, <Vn>.<Ta>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
```

## Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Tb> Is an arrangement specifier, encoded in "size:Q":

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<Ta> Is an arrangement specifier, encoded in "size":

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vb> Is the destination width specifier, encoded in "size":

size	<Vb>
00	B
01	H
10	S
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Va> Is the source width specifier, encoded in "size":

size	<Va>
00	H
01	S
10	D
11	RESERVED

<n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(2*datasize) operand = V[n];
bits(datasize) result;
bits(2*esize) element;
boolean sat;

for e = 0 to elements-1
    element = Elem[operand, e, 2*esize];
    (Elem[result, e, esize], sat) = SatQ(Int(element, unsigned), esize, unsigned);
    if sat then FPSR.QC = '1';

Vpart[d, part] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

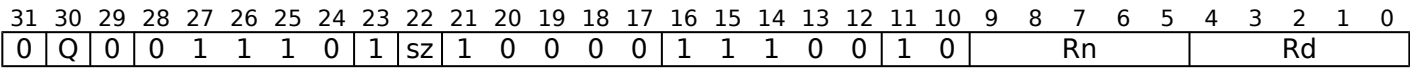
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



URECPE

Unsigned Reciprocal Estimate. This instruction reads each vector element from the source SIMD&FP register, calculates an approximate inverse for the unsigned integer value, places the result into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



URECPE <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz == '1' then UNDEFINED;
integer esize = 32;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	x	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(32) element;

for e = 0 to elements-1
    element = Elem[operand, e, 32];
    Elem[result, e, 32] = UnsignedRecipEstimate(element);

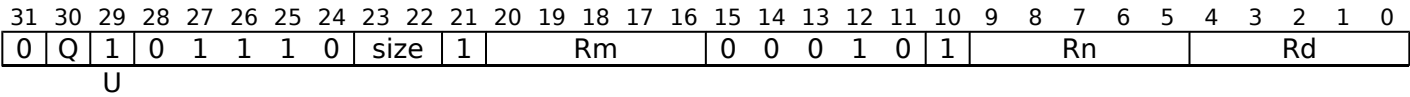
V[d] = result;
```

URHADD

Unsigned Rounding Halving Add. This instruction adds corresponding unsigned integer values from the two source SIMD&FP registers, shifts each result right one bit, places the results into a vector, and writes the vector to the destination SIMD&FP register.

The results are rounded. For truncated results, see [UHADD](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



URHADD <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    Elem[result, e, esize] = (element1+element2+1)<esize:1>;

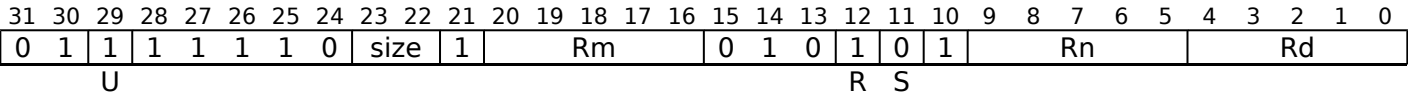
V[d] = result;
```

URSHL

Unsigned Rounding Shift Left (register). This instruction takes each element in the vector of the first source SIMD&FP register, shifts the vector element by a value from the least significant byte of the corresponding element of the second source SIMD&FP register, places the results in a vector, and writes the vector to the destination SIMD&FP register. If the shift value is positive, the operation is a left shift. If the shift value is negative, it is a rounding right shift. Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: Scalar and Vector

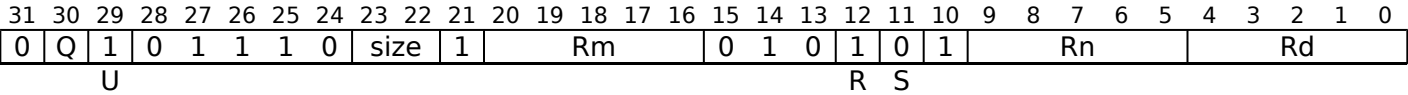
Scalar



URSHL <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
if S == '0' && size != '11' then UNDEFINED;
```

Vector



URSHL <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D

<d> Is the number of the SIMD&FP destination register, in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

integer round_const = 0;
integer shift;
integer element;
boolean sat;

for e = 0 to elements-1
    shift = SInt(Elem[operand2, e, esize]<7:0>);
    if rounding then
        round_const = 1 << (-shift - 1);    // 0 for left shift, 2^(n-1) for right shift
    element = (Int(Elem[operand1, e, esize], unsigned) + round_const) << shift;
    if saturating then
        (Elem[result, e, esize], sat) = SatQ(element, esize, unsigned);
        if sat then FPSR.QC = '1';
    else
        Elem[result, e, esize] = element<esize-1:0>;

V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

URSHR

Unsigned Rounding Shift Right (immediate). This instruction reads each vector element in the source SIMD&FP register, right shifts each result by an immediate value, writes the final result to a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are unsigned integer values. The results are rounded. For truncated results, see [USHR](#). Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	1	0	!= 0000				immb		0	0	1	0	0	1	Rn				Rd						
U									immh				o1 o0																		

URSHR <V><d>, <V><n>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh<3> != '1' then UNDEFINED;
integer esize = 8 << 3;
integer datasize = esize;
integer elements = 1;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	0	!= 0000				immb		0	0	1	0	0	1	Rn				Rd						
U									immh						o1		o0														

URSHR <Vd>.<T>, <Vn>.<T>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3>:Q == '10' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “immh”:

immh	<V>
0xxx	RESERVED
1xxx	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.
- <shift> For the scalar variant: is the right shift amount, in the range 1 to 64, encoded in "immh:immb":

immh	<shift>
0xxx	RESERVED
1xxx	(128-UInt(immh:immb))

For the vector variant: is the right shift amount, in the range 1 to the element width in bits, encoded in "immh:immb":

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

## Operation

```

CheckFPAdvSIMDEnabled64\(\);
bits(datasize) operand = V[n];
bits(datasize) operand2;
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;

operand2 = if accumulate then V[d] else Zeros\(\);
for e = 0 to elements-1
    element = (Int(Elem[operand, e, esize], unsigned) + round_const) >> shift;
    Elem[result, e, esize] = Elem[operand2, e, esize] + element<esize-1:0>;
V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# URSQRTE

Unsigned Reciprocal Square Root Estimate. This instruction reads each vector element from the source SIMD&FP register, calculates an approximate inverse square root for each value, places the result into a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are unsigned integer values.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	sz	1	0	0	0	0	1	1	1	0	0	1	0	Rn				Rd					

URSQRTE <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz == '1' then UNDEFINED;
integer esize = 32;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

## Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	x	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(32) element;

for e = 0 to elements-1
    element = Elem[operand, e, 32];
    Elem[result, e, 32] = UnsignedRSqrtEstimate(element);

V[d] = result;
```

URSRA

Unsigned Rounding Shift Right and Accumulate (immediate). This instruction reads each vector element in the source SIMD&FP register, right shifts each result by an immediate value, and accumulates the final results with the vector elements of the destination SIMD&FP register. All the values in this instruction are unsigned integer values. The results are rounded. For truncated results, see [USRA](#).  
Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	1	0	!= 0000				immb		0	0	1	1	0	1	Rn				Rd						
U									immh				o1 o0																		

URSRA <V><d>, <V><n>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh<3> != '1' then UNDEFINED;
integer esize = 8 << 3;
integer datasize = esize;
integer elements = 1;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	0	!= 0000				immb		0	0	1	1	0	1	Rn				Rd						
U									immh				o1 o0																		

URSRA <Vd>.<T>, <Vn>.<T>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3>:Q == '10' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “immh”:

immh	<V>
0xxx	RESERVED
1xxx	D



- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.
- <shift> For the scalar variant: is the right shift amount, in the range 1 to 64, encoded in "immh:immb":

immh	<shift>
0xxx	RESERVED
1xxx	(128-UInt(immh:immb))

For the vector variant: is the right shift amount, in the range 1 to the element width in bits, encoded in "immh:immb":

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

## Operation

```

CheckFPAdvSIMDEnabled64\(\);
bits(datasize) operand = V[n];
bits(datasize) operand2;
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;

operand2 = if accumulate then V[d] else Zeros\(\);
for e = 0 to elements-1
    element = (Int(Elem[operand, e, esize], unsigned) + round_const) >> shift;
    Elem[result, e, esize] = Elem[operand2, e, esize] + element<esize-1:0>;
V[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

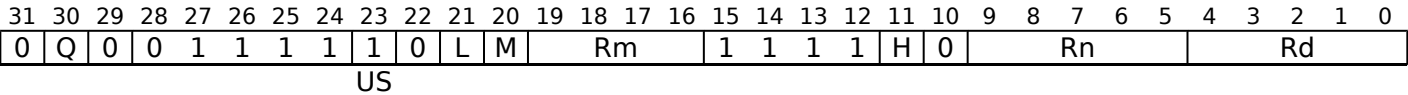
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

USDOT (by element)

Dot Product index form with unsigned and signed integers. This instruction performs the dot product of the four unsigned 8-bit integer values in each 32-bit element of the first source register with the four signed 8-bit integer values in an indexed 32-bit element of the second source register, accumulating the result into the corresponding 32-bit element of the destination register.

From Armv8.2 to Armv8.5, this is an OPTIONAL instruction. From Armv8.6 it is mandatory for implementations that include Advanced SIMD to support it. [ID\\_AA64ISAR1\\_EL1](#).I8MM indicates whether this instruction is supported.

Vector  
(FEAT\_I8MM)



USDOT <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.4B[<index>]

```
if !HaveInt8MatMulExt() then UNDEFINED;
boolean op1_unsigned = (US == '1');
boolean op2_unsigned = (US == '0');
integer n = UInt(Rn);
integer m = UInt(M:Rm);
integer d = UInt(Rd);
integer i = UInt(H:L);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV 32;
```

Assembler Symbols

- <Vd>

Is the name of the SIMD&FP third source and destination register, encoded in the "Rd" field.
- <Ta>

Is an arrangement specifier, encoded in "Q":

Q	<Ta>
0	2S
1	4S
- <Vn>

Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Tb>

Is an arrangement specifier, encoded in "Q":

Q	<Tb>
0	8B
1	16B
- <Vm>

Is the name of the second SIMD&FP source register, encoded in the "M:Rm" fields.
- <index>

Is the immediate index of a quadruplet of four 8-bit elements in the range 0 to 3, encoded in the "H:L" fields.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(128) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;

for e = 0 to elements-1
    bits(32) res = Elem[operand3, e, 32];
    for b = 0 to 3
        integer element1 = Int(Elem[operand1, 4*e+b, 8], op1_unsigned);
        integer element2 = Int(Elem[operand2, 4*i+b, 8], op2_unsigned);
        res = res + element1 * element2;
    Elem[result, e, 32] = res;
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# USDOT (vector)

Dot Product vector form with unsigned and signed integers. This instruction performs the dot product of the four unsigned 8-bit integer values in each 32-bit element of the first source register with the four signed 8-bit integer values in the corresponding 32-bit element of the second source register, accumulating the result into the corresponding 32-bit element of the destination register.

From Armv8.2 to Armv8.5, this is an OPTIONAL instruction. From Armv8.6 it is mandatory for implementations that include Advanced SIMD to support it. [ID\\_AA64ISAR1\\_EL1](#).I8MM indicates whether this instruction is supported.

## Vector (FEAT\_I8MM)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	0	0	Rm				1	0	0	1	1	1	Rn				Rd						

USDOT <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
if !HaveInt8MatMulExt() then UNDEFINED;
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Rd);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV 32;
```

## Assembler Symbols

- <Vd>

Is the name of the SIMD&FP third source and destination register, encoded in the "Rd" field.
- <Ta>

Is an arrangement specifier, encoded in "Q":

Q	<Ta>
0	2S
1	4S
- <Vn>

Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Tb>

Is an arrangement specifier, encoded in "Q":

Q	<Tb>
0	8B
1	16B
- <Vm>

Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;

for e = 0 to elements-1
    bits(32) res = Elem[operand3, e, 32];
    for b = 0 to 3
        integer element1 = UInt(Elem[operand1, 4*e+b, 8]);
        integer element2 = SInt(Elem[operand2, 4*e+b, 8]);
        res = res + element1 * element2;
    Elem[result, e, 32] = res;

V[d] = result;
```

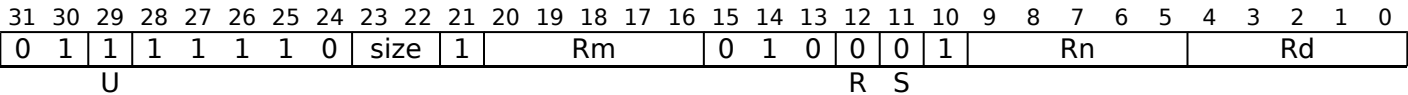


USHL

Unsigned Shift Left (register). This instruction takes each element in the vector of the first source SIMD&FP register, shifts each element by a value from the least significant byte of the corresponding element of the second source SIMD&FP register, places the results in a vector, and writes the vector to the destination SIMD&FP register. If the shift value is positive, the operation is a left shift. If the shift value is negative, it is a truncating right shift. For a rounding shift, see [URSHL](#). Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

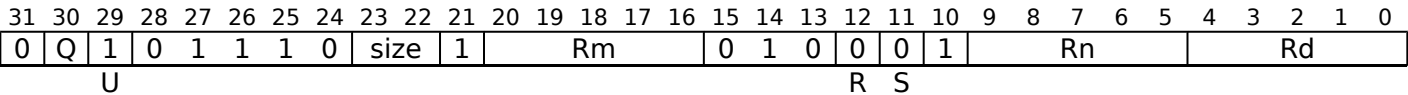
Scalar



USHL <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
if S == '0' && size != '11' then UNDEFINED;
```

Vector



USHL <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D

<d> Is the number of the SIMD&FP destination register, in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

integer round_const = 0;
integer shift;
integer element;
boolean sat;

for e = 0 to elements-1
    shift = SInt(Elem[operand2, e, esize]<7:0>);
    if rounding then
        round_const = 1 << (-shift - 1);    // 0 for left shift, 2^(n-1) for right shift
    element = (Int(Elem[operand1, e, esize], unsigned) + round_const) << shift;
    if saturating then
        (Elem[result, e, esize], sat) = SatQ(element, esize, unsigned);
        if sat then FPSR.QC = '1';
    else
        Elem[result, e, esize] = element<esize-1:0>;

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

USHLL, USHLL2

Unsigned Shift Left Long (immediate). This instruction reads each vector element in the lower or upper half of the source SIMD&FP register, shifts the unsigned integer value left by the specified number of bits, places the result into a vector, and writes the vector to the destination SIMD&FP register. The destination vector elements are twice as long as the source vector elements.

The USHLL instruction extracts vector elements from the lower half of the source register, while the USHLL2 instruction extracts vector elements from the upper half of the source register.

Depending on the settings in the [CPACR EL1](#), [CPTR EL2](#), and [CPTR EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This instruction is used by the alias [UXTL](#), [UXTL2](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	0	!= 0000				immb			1	0	1	0	0	1	Rn				Rd					
U									immh																						

USHLL{2} <Vd>.<Ta>, <Vn>.<Tb>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = 64;
integer part = UInt(0);
integer elements = datasize DIV esize;

integer shift = UInt(immh:immb) - esize;
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q		2
0		[absent]
1		[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “immh”:

immh	<Ta>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	8H
001x	4S
01xx	2D
1xxx	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “immh:Q”:



immh	Q	<Tb>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	x	RESERVED

<shift> Is the left shift amount, in the range 0 to the source element width in bits minus 1, encoded in “immh:immb”:

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(UInt(immh:immb)-8)
001x	(UInt(immh:immb)-16)
01xx	(UInt(immh:immb)-32)
1xxx	RESERVED

## Alias Conditions

Alias	Is preferred when
<a href="#">UXTL, UXTL2</a>	immb == '000' && <a href="#">BitCount</a> (immh) == 1

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = Vpart[n, part];
bits(datasize*2) result;
integer element;

for e = 0 to elements-1
    element = Int(Elem[operand, e, esize], unsigned) << shift;
    Elem[result, e, 2*esize] = element<2*esize-1:0>;

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

USHR

Unsigned Shift Right (immediate). This instruction reads each vector element in the source SIMD&FP register, right shifts each result by an immediate value, writes the final result to a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are unsigned integer values. The results are truncated. For rounded results, see [URSHR](#).  
Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	1	0	!= 0000				immb			0	0	0	0	0	1	Rn						Rd			
U									immh				o1 o0																		

USHR [<V><d>](#), [<V><n>](#), [#<shift>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh<3> != '1' then UNDEFINED;
integer esize = 8 << 3;
integer datasize = esize;
integer elements = 1;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	0	!= 0000				immb			0	0	0	0	0	1	Rn						Rd			
U									immh				o1 o0																		

USHR [<Vd>.<T>](#), [<Vn>.<T>](#), [#<shift>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE\(asimdimm\);
if immh<3>:Q == '10' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

Assembler Symbols

[<V>](#) Is a width specifier, encoded in “immh”:

immh	<a href="#">&lt;V&gt;</a>
0xxx	RESERVED
1xxx	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.
- <shift> For the scalar variant: is the right shift amount, in the range 1 to 64, encoded in "immh:immb":

immh	<shift>
0xxx	RESERVED
1xxx	(128-UInt(immh:immb))

For the vector variant: is the right shift amount, in the range 1 to the element width in bits, encoded in "immh:immb":

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) operand2;
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;

operand2 = if accumulate then V[d] else Zeros();
for e = 0 to elements-1
    element = (Int(Elem[operand, e, esize], unsigned) + round_const) >> shift;
    Elem[result, e, esize] = Elem[operand2, e, esize] + element<esize-1:0>;

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

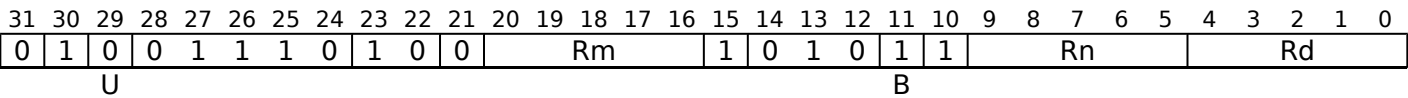
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# USMMLA (vector)

Unsigned and signed 8-bit integer matrix multiply-accumulate. This instruction multiplies the 2x8 matrix of unsigned 8-bit integer values in the first source vector by the 8x2 matrix of signed 8-bit integer values in the second source vector. The resulting 2x2 32-bit integer matrix product is destructively added to the 32-bit integer matrix accumulator in the destination vector. This is equivalent to performing an 8-way dot product per destination element. From Armv8.2 to Armv8.5, this is an OPTIONAL instruction. From Armv8.6 it is mandatory for implementations that include Advanced SIMD to support it. [ID\\_AA64ISAR1\\_EL1](#).I8MM indicates whether this instruction is supported.

## Vector (FEAT\_I8MM)



USMMLA <Vd>.4S, <Vn>.16B, <Vm>.16B

```
if !HaveInt8MatMulExt() then UNDEFINED;
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Rd);
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP third source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(128) operand1 = V[n];
bits(128) operand2 = V[m];
bits(128) addend = V[d];

V[d] = MatMulAdd(addend, operand1, operand2, TRUE, FALSE);
```

# USQADD

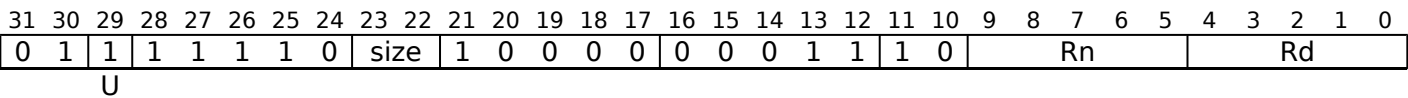
Unsigned saturating Accumulate of Signed value. This instruction adds the signed integer values of the vector elements in the source SIMD&FP register to corresponding unsigned integer values of the vector elements in the destination SIMD&FP register, and accumulates the resulting unsigned integer values with the vector elements of the destination SIMD&FP register.

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit *FPSR.QC* is set.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar



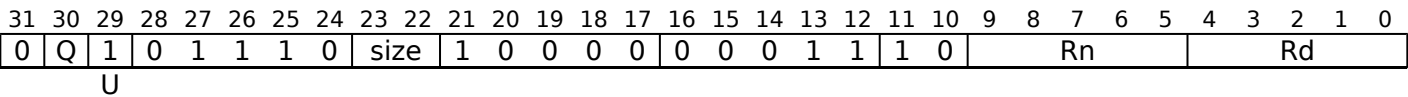
USQADD <V><d>, <V><n>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;

boolean unsigned = (U == '1');
```

## Vector



USQADD <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
```

## Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D

<d> Is the number of the SIMD&FP destination register, encoded in the “Rd” field.

<n> Is the number of the SIMD&FP source register, encoded in the “Rn” field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;

bits(datasize) operand2 = V[d];
integer op1;
integer op2;
boolean sat;

for e = 0 to elements-1
    op1 = Int(Elem[operand, e, esize], !unsigned);
    op2 = Int(Elem[operand2, e, esize], unsigned);
    (Elem[result, e, esize], sat) = Sat0(op1 + op2, esize, unsigned);
    if sat then FPSR.QC = '1';
V[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

USRA

Unsigned Shift Right and Accumulate (immediate). This instruction reads each vector element in the source SIMD&FP register, right shifts each result by an immediate value, and accumulates the final results with the vector elements of the destination SIMD&FP register. All the values in this instruction are unsigned integer values. The results are truncated. For rounded results, see [URSRA](#).  
Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	1	0	!= 0000				immb			0	0	0	1	0	1	Rn						Rd			
U									immh				o1			o0															

USRA [<V><d>](#), [<V><n>](#), [#<shift>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh<3> != '1' then UNDEFINED;
integer esize = 8 << 3;
integer datasize = esize;
integer elements = 1;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	0	!= 0000				immb			0	0	0	1	0	1	Rn						Rd			
U									immh				o1			o0															

USRA [<Vd>.<T>](#), [<Vn>.<T>](#), [#<shift>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3>:Q == '10' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

Assembler Symbols

[<V>](#) Is a width specifier, encoded in “immh”:

immh	<V>
0xxx	RESERVED
1xxx	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.
- <shift> For the scalar variant: is the right shift amount, in the range 1 to 64, encoded in "immh:immb":

immh	<shift>
0xxx	RESERVED
1xxx	(128-UInt(immh:immb))

For the vector variant: is the right shift amount, in the range 1 to the element width in bits, encoded in "immh:immb":

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) operand2;
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;

operand2 = if accumulate then V[d] else Zeros();
for e = 0 to elements-1
    element = (Int(Elem[operand, e, esize], unsigned) + round_const) >> shift;
    Elem[result, e, esize] = Elem[operand2, e, esize] + element<esize-1:0>;

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

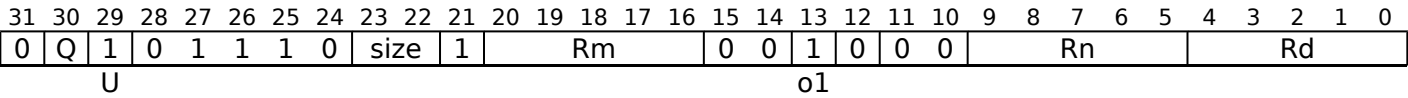
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



USUBL, USUBL2

Unsigned Subtract Long. This instruction subtracts each vector element in the lower or upper half of the second source SIMD&FP register from the corresponding vector element of the first source SIMD&FP register, places the result into a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are unsigned integer values. The destination vector elements are twice as long as the source vector elements. The USUBL instruction extracts each source vector from the lower half of each source register, while the USUBL2 instruction extracts each source vector from the upper half of each source register. Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



USUBL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean sub_op = (o1 == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q 2	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
integer element1;
integer element2;
integer sum;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    if sub_op then
        sum = element1 - element2;
    else
        sum = element1 + element2;
    Elem[result, e, 2*esize] = sum<2*esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

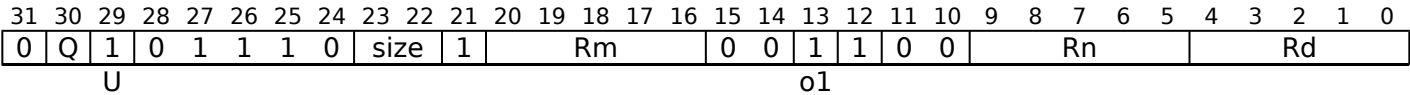
USUBW, USUBW2

Unsigned Subtract Wide. This instruction subtracts each vector element of the second source SIMD&FP register from the corresponding vector element in the lower or upper half of the first source SIMD&FP register, places the result in a vector, and writes the vector to the SIMD&FP destination register. All the values in this instruction are signed integer values.

The vector elements of the destination register and the first source register are twice as long as the vector elements of the second source register.

The USUBW instruction extracts vector elements from the lower half of the first source register, while the USUBW2 instruction extracts vector elements from the upper half of the first source register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



USUBW{2} <Vd>.<Ta>, <Vn>.<Ta>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean sub_op = (o1 == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(2*datasize) operand1 = V[n];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
integer element1;
integer element2;
integer sum;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, 2*esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    if sub_op then
        sum = element1 - element2;
    else
        sum = element1 + element2;
    Elem[result, e, 2*esize] = sum<2*esize-1:0>;

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UXTL, UXTL2

Unsigned extend Long. This instruction copies each vector element from the lower or upper half of the source SIMD&FP register into a vector, and writes the vector to the destination SIMD&FP register. The destination vector elements are twice as long as the source vector elements.

The UXTL instruction extracts vector elements from the lower half of the source register, while the UXTL2 instruction extracts vector elements from the upper half of the source register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This is an alias of [USHLL](#), [USHLL2](#). This means:

- The encodings in this description are named to match the encodings of [USHLL](#), [USHLL2](#).
- The description of [USHLL](#), [USHLL2](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	0	!= 0000				0	0	0	1	0	1	0	0	1	Rn				Rd					
U									immh				immb																		

UXTL{2} <Vd>.<Ta>, <Vn>.<Tb>

is equivalent to

USHLL{2} <Vd>.<Ta>, <Vn>.<Tb>, #0

and is the preferred disassembly when BitCount(immh) == 1.

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q		2
0		[absent]
1		[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “immh”:

immh	<Ta>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	8H
001x	4S
01xx	2D
1xxx	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “immh:Q”:

immh	Q	<Tb>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	x	RESERVED

## Operation

The description of [USHLL](#), [USHLL2](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

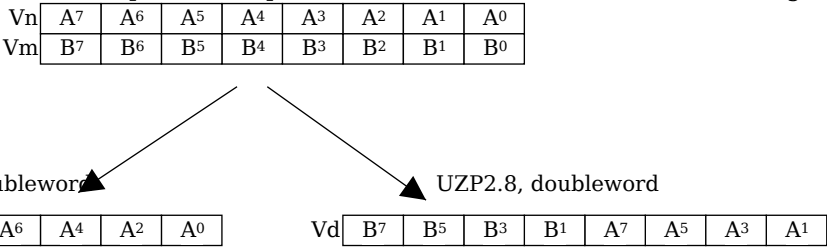
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UZP1

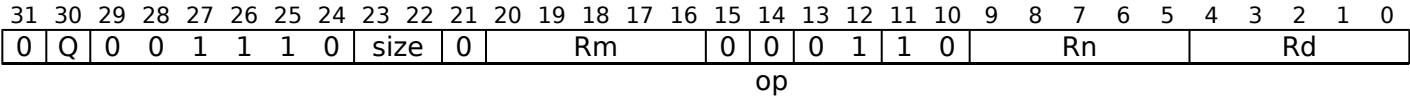
Unzip vectors (primary). This instruction reads corresponding even-numbered vector elements from the two source SIMD&FP registers, starting at zero, places the result from the first source register into consecutive elements in the lower half of a vector, and the result from the second source register into consecutive elements in the upper half of a vector, and writes the vector to the destination SIMD&FP register.

This instruction can be used with UZP2 to de-interleave two vectors.

The following figure shows an example of the operation of UZP1 and UZP2 with the arrangement specifier 8B.



Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



UZP1 <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
integer part = UInt(op);
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operandl = V[n];
bits(datasize) operandh = V[m];
bits(datasize) result;

bits(datasize*2) zipped = operandh:operandl;
for e = 0 to elements-1
    Elem[result, e, esize] = Elem[zipped, 2*e+part, esize];

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

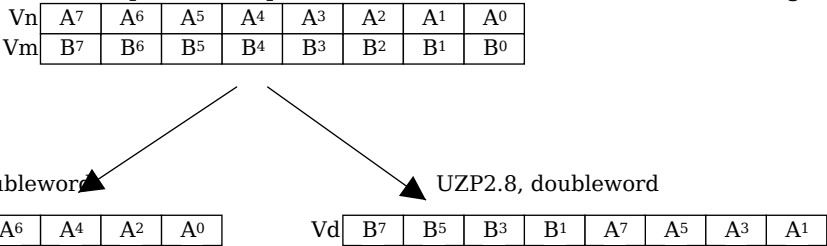


UZP2

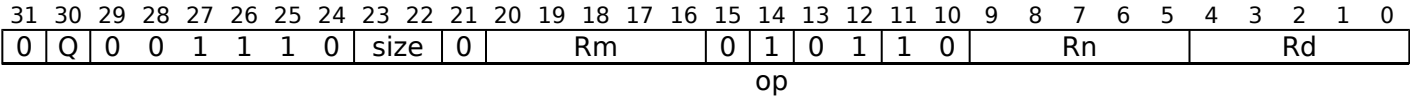
Unzip vectors (secondary). This instruction reads corresponding odd-numbered vector elements from the two source SIMD&FP registers, places the result from the first source register into consecutive elements in the lower half of a vector, and the result from the second source register into consecutive elements in the upper half of a vector, and writes the vector to the destination SIMD&FP register.

This instruction can be used with UZP1 to de-interleave two vectors.

The following figure shows an example of the operation of UZP1 and UZP2 with the arrangement specifier 8B.



Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



UZP2 <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
integer part = UInt(op);
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operandl = V[n];
bits(datasize) operandh = V[m];
bits(datasize) result;

bits(datasize*2) zipped = operandh:operandl;
for e = 0 to elements-1
    Elem[result, e, esize] = Elem[zipped, 2*e+part, esize];

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# XAR

Exclusive OR and Rotate performs a bitwise exclusive OR of the 128-bit vectors in the two source SIMD&FP registers, rotates each 64-bit element of the resulting 128-bit vector right by the value specified by a 6-bit immediate value, and writes the result to the destination SIMD&FP register.

This instruction is implemented only when **FEAT\_SHA3** is implemented.

## Advanced SIMD (FEAT\_SHA3)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	1	0	0	Rm				imm6						Rn				Rd						

XAR <Vd>.2D, <Vn>.2D, <Vm>.2D, #<imm6>

```
if !HaveSHA3Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.
- <imm6> Is a rotation right, encoded in "imm6".

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) Vm = V[m];
bits(128) Vn = V[n];
bits(128) tmp;
tmp = Vn EOR Vm;
V[d] = ROR(tmp<127:64>, UInt(imm6)):ROR(tmp<63:0>, UInt(imm6));
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

XTN, XTN2

Extract Narrow. This instruction reads each vector element from the source SIMD&FP register, narrows each value to half the original width, places the result into a vector, and writes the vector to the lower or upper half of the destination SIMD&FP register. The destination vector elements are half as long as the source vector elements. The XTN instruction writes the vector to the lower half of the destination register and clears the upper half, while the XTN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	size		1	0	0	0	0	1	0	0	1	0	1	0	Rn				Rd					

```
XTN{2} <Vd>.<Tb>, <Vn>.<Ta>

integer d = UInt(Rd);
integer n = UInt(Rn);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q 2	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(2*datasize) operand = V[n];
bits(datasize) result;
bits(2*esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, 2*esize];
    Elem[result, e, esize] = element<esize-1:0>;
Vpart[d, part] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

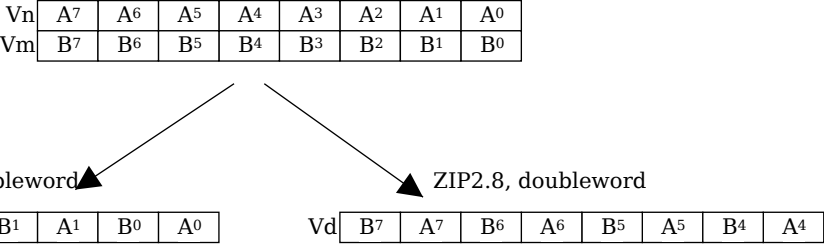
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

ZIP1

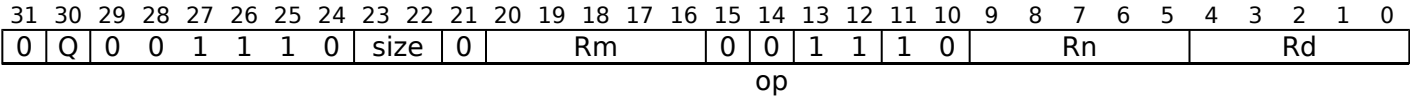
Zip vectors (primary). This instruction reads adjacent vector elements from the lower half of two source SIMD&FP registers as pairs, interleaves the pairs and places them into a vector, and writes the vector to the destination SIMD&FP register. The first pair from the first source register is placed into the two lowest vector elements, with subsequent pairs taken alternately from each source register.

This instruction can be used with ZIP2 to interleave two vectors.

The following figure shows an example of the operation of ZIP1 and ZIP2 with the arrangement specifier 8B.



Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



ZIP1 <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
integer part = UInt(op);
integer pairs = elements DIV 2;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

integer base = part * pairs;

for p = 0 to pairs-1
    Elem[result, 2*p+0, esize] = Elem[operand1, base+p, esize];
    Elem[result, 2*p+1, esize] = Elem[operand2, base+p, esize];

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

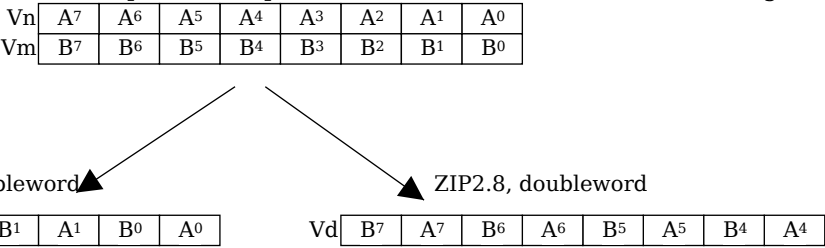
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

ZIP2

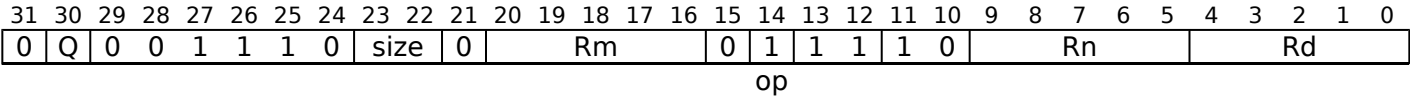
Zip vectors (secondary). This instruction reads adjacent vector elements from the upper half of two source SIMD&FP registers as pairs, interleaves the pairs and places them into a vector, and writes the vector to the destination SIMD&FP register. The first pair from the first source register is placed into the two lowest vector elements, with subsequent pairs taken alternately from each source register.

This instruction can be used with ZIP1 to interleave two vectors.

The following figure shows an example of the operation of ZIP1 and ZIP2 with the arrangement specifier 8B.



Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



ZIP2 <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
integer part = UInt(op);
integer pairs = elements DIV 2;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.



## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

integer base = part * pairs;

for p = 0 to pairs-1
    Elem[result, 2*p+0, esize] = Elem[operand1, base+p, esize];
    Elem[result, 2*p+1, esize] = Elem[operand2, base+p, esize];

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## A64 -- SVE Instructions (alphabetic order)

[ABS](#): Absolute value (predicated).

[ADD \(immediate\)](#): Add immediate (unpredicated).

[ADD \(vectors, predicated\)](#): Add vectors (predicated).

[ADD \(vectors, unpredicated\)](#): Add vectors (unpredicated).

[ADDPL](#): Add multiple of predicate register size to scalar register.

[ADDVL](#): Add multiple of vector register size to scalar register.

[ADR](#): Compute vector address.

[AND \(immediate\)](#): Bitwise AND with immediate (unpredicated).

[AND \(vectors, predicated\)](#): Bitwise AND vectors (predicated).

[AND \(vectors, unpredicated\)](#): Bitwise AND vectors (unpredicated).

[AND, ANDS \(predicates\)](#): Bitwise AND predicates.

[ANDV](#): Bitwise AND reduction to scalar.

[ASR \(immediate, predicated\)](#): Arithmetic shift right by immediate (predicated).

[ASR \(immediate, unpredicated\)](#): Arithmetic shift right by immediate (unpredicated).

[ASR \(vectors\)](#): Arithmetic shift right by vector (predicated).

[ASR \(wide elements, predicated\)](#): Arithmetic shift right by 64-bit wide elements (predicated).

[ASR \(wide elements, unpredicated\)](#): Arithmetic shift right by 64-bit wide elements (unpredicated).

[ASRD](#): Arithmetic shift right for divide by immediate (predicated).

[ASRR](#): Reversed arithmetic shift right by vector (predicated).

[BFCVT](#): Floating-point down convert to BFloat16 format (predicated).

[BFCVTNT](#): Floating-point down convert and narrow to BFloat16 (top, predicated).

[BFDOT \(indexed\)](#): BFloat16 floating-point indexed dot product.

[BFDOT \(vectors\)](#): BFloat16 floating-point dot product.

[BFMLALB \(indexed\)](#): BFloat16 floating-point multiply-add long to single-precision (bottom, indexed).

[BFMLALB \(vectors\)](#): BFloat16 floating-point multiply-add long to single-precision (bottom).

[BFMLALT \(indexed\)](#): BFloat16 floating-point multiply-add long to single-precision (top, indexed).

[BFMLALT \(vectors\)](#): BFloat16 floating-point multiply-add long to single-precision (top).

[BFMMLA](#): BFloat16 floating-point matrix multiply-accumulate.

[BIC \(immediate\)](#): Bitwise clear bits using immediate (unpredicated): an alias of AND (immediate).

[BIC \(vectors, predicated\)](#): Bitwise clear vectors (predicated).

[BIC \(vectors, unpredicated\)](#): Bitwise clear vectors (unpredicated).

[BIC, BICS \(predicates\)](#): Bitwise clear predicates.

[BRKA, BRKAS](#): Break after first true condition.

[BRKB, BRKBS](#): Break before first true condition.

[BRKN, BRKNS](#): Propagate break to next partition.

[BRKPA, BRKPAS](#): Break after first true condition, propagating from previous partition.

[BRKPB, BRKPBS](#): Break before first true condition, propagating from previous partition.

[CLASTA \(scalar\)](#): Conditionally extract element after last to general-purpose register.

[CLASTA \(SIMD&FP scalar\)](#): Conditionally extract element after last to SIMD&FP scalar register.

[CLASTA \(vectors\)](#): Conditionally extract element after last to vector register.

[CLASTB \(scalar\)](#): Conditionally extract last element to general-purpose register.

[CLASTB \(SIMD&FP scalar\)](#): Conditionally extract last element to SIMD&FP scalar register.

[CLASTB \(vectors\)](#): Conditionally extract last element to vector register.

[CLS](#): Count leading sign bits (predicated).

[CLZ](#): Count leading zero bits (predicated).

[CMP<cc> \(immediate\)](#): Compare vector to immediate.

[CMP<cc> \(vectors\)](#): Compare vectors.

[CMP<cc> \(wide elements\)](#): Compare vector to 64-bit wide elements.

[CMPLE \(vectors\)](#): Compare signed less than or equal to vector, setting the condition flags: an alias of CMP<cc> (vectors).

[CMPLO \(vectors\)](#): Compare unsigned lower than vector, setting the condition flags: an alias of CMP<cc> (vectors).

[CMPLS \(vectors\)](#): Compare unsigned lower or same as vector, setting the condition flags: an alias of CMP<cc> (vectors).

[CMPLT \(vectors\)](#): Compare signed less than vector, setting the condition flags: an alias of CMP<cc> (vectors).

[CNOT](#): Logically invert boolean condition in vector (predicated).

[CNT](#): Count non-zero bits (predicated).

[CNTB, CNTD, CNTH, CNTW](#): Set scalar to multiple of predicate constraint element count.

[CNTP](#): Set scalar to count of true predicate elements.

[COMPACT](#): Shuffle active elements of vector to the right and fill with zero.

[CPY \(immediate, merging\)](#): Copy signed integer immediate to vector elements (merging).

[CPY \(immediate, zeroing\)](#): Copy signed integer immediate to vector elements (zeroing).

[CPY \(scalar\)](#): Copy general-purpose register to vector elements (predicated).

[CPY \(SIMD&FP scalar\)](#): Copy SIMD&FP scalar register to vector elements (predicated).

[CTERMEQ, CTERMNE](#): Compare and terminate loop.

[DECB, DECD, DECH, DECW \(scalar\)](#): Decrement scalar by multiple of predicate constraint element count.

[DECD, DECH, DECW \(vector\)](#): Decrement vector by multiple of predicate constraint element count.

[DECP \(scalar\)](#): Decrement scalar by count of true predicate elements.

[DECP \(vector\)](#): Decrement vector by count of true predicate elements.

[DUP \(immediate\)](#): Broadcast signed immediate to vector elements (unpredicated).

[DUP \(indexed\)](#): Broadcast indexed element to vector (unpredicated).

[DUP \(scalar\)](#): Broadcast general-purpose register to vector elements (unpredicated).

[DUPM](#): Broadcast logical bitmask immediate to vector (unpredicated).

[EON](#): Bitwise exclusive OR with inverted immediate (unpredicated): an alias of EOR (immediate).

[EOR \(immediate\)](#): Bitwise exclusive OR with immediate (unpredicated).

[EOR \(vectors, predicated\)](#): Bitwise exclusive OR vectors (predicated).

[EOR \(vectors, unpredicated\)](#): Bitwise exclusive OR vectors (unpredicated).

[EOR, EORS \(predicates\)](#): Bitwise exclusive OR predicates.

[EORV](#): Bitwise exclusive OR reduction to scalar.

[EXT](#): Extract vector from pair of vectors.

[FABD](#): Floating-point absolute difference (predicated).

[FABS](#): Floating-point absolute value (predicated).

[FAC<cc>](#): Floating-point absolute compare vectors.

[FACLE](#): Floating-point absolute compare less than or equal: an alias of FAC<cc>.

[FACLT](#): Floating-point absolute compare less than: an alias of FAC<cc>.

[FADD \(immediate\)](#): Floating-point add immediate (predicated).

[FADD \(vectors, predicated\)](#): Floating-point add vector (predicated).

[FADD \(vectors, unpredicated\)](#): Floating-point add vector (unpredicated).

[FADDA](#): Floating-point add strictly-ordered reduction, accumulating in scalar.

[FADDV](#): Floating-point add recursive reduction to scalar.

[FCADD](#): Floating-point complex add with rotate (predicated).

[FCM<cc> \(vectors\)](#): Floating-point compare vectors.

[FCM<cc> \(zero\)](#): Floating-point compare vector with zero.

[FCMLA \(indexed\)](#): Floating-point complex multiply-add by indexed values with rotate.

[FCMLA \(vectors\)](#): Floating-point complex multiply-add with rotate (predicated).

[FCMLE \(vectors\)](#): Floating-point compare less than or equal to vector: an alias of FCM<cc> (vectors).

[FCMLT \(vectors\)](#): Floating-point compare less than vector: an alias of FCM<cc> (vectors).

[FCPY](#): Copy 8-bit floating-point immediate to vector elements (predicated).

[FCVT](#): Floating-point convert precision (predicated).

[FCVTZS](#): Floating-point convert to signed integer, rounding toward zero (predicated).

[FCVTZU](#): Floating-point convert to unsigned integer, rounding toward zero (predicated).

[FDIV](#): Floating-point divide by vector (predicated).

[FDIVR](#): Floating-point reversed divide by vector (predicated).

[FDUP](#): Broadcast 8-bit floating-point immediate to vector elements (unpredicated).

[FEXPA](#): Floating-point exponential accelerator.

[FMAD](#): Floating-point fused multiply-add vectors (predicated), writing multiplicand [ $Z_{dn} = Z_a + Z_{dn} * Z_m$ ].

[FMAX \(immediate\)](#): Floating-point maximum with immediate (predicated).

[FMAX \(vectors\)](#): Floating-point maximum (predicated).

[FMAXNM \(immediate\)](#): Floating-point maximum number with immediate (predicated).

[FMAXNM \(vectors\)](#): Floating-point maximum number (predicated).

[FMAXNMV](#): Floating-point maximum number recursive reduction to scalar.

[FMAXV](#): Floating-point maximum recursive reduction to scalar.

[FMIN \(immediate\)](#): Floating-point minimum with immediate (predicated).

[FMIN \(vectors\)](#): Floating-point minimum (predicated).

[FMINNM \(immediate\)](#): Floating-point minimum number with immediate (predicated).

[FMINNM \(vectors\)](#): Floating-point minimum number (predicated).

[FMINNMV](#): Floating-point minimum number recursive reduction to scalar.

[FMINV](#): Floating-point minimum recursive reduction to scalar.

[FMLA \(indexed\)](#): Floating-point fused multiply-add by indexed elements ( $Z_{da} = Z_{da} + Z_n * Z_m[\text{indexed}]$ ).

[FMLA \(vectors\)](#): Floating-point fused multiply-add vectors (predicated), writing addend [ $Z_{da} = Z_{da} + Z_n * Z_m$ ].

[FMLS \(indexed\)](#): Floating-point fused multiply-subtract by indexed elements ( $Z_{da} = Z_{da} + -Z_n * Z_m[\text{indexed}]$ ).

[FMLS \(vectors\)](#): Floating-point fused multiply-subtract vectors (predicated), writing addend [ $Z_{da} = Z_{da} + -Z_n * Z_m$ ].

[FMMLA](#): Floating-point matrix multiply-accumulate.

[FMOV \(immediate, predicated\)](#): Move 8-bit floating-point immediate to vector elements (predicated): an alias of FCPY.

[FMOV \(immediate, unpredicated\)](#): Move 8-bit floating-point immediate to vector elements (unpredicated): an alias of FDUP.

[FMOV \(zero, predicated\)](#): Move floating-point +0.0 to vector elements (predicated): an alias of CPY (immediate, merging).

[FMOV \(zero, unpredicated\)](#): Move floating-point +0.0 to vector elements (unpredicated): an alias of DUP (immediate).

[FMSB](#): Floating-point fused multiply-subtract vectors (predicated), writing multiplicand [ $Z_{dn} = Z_a + -Z_{dn} * Z_m$ ].

[FMUL \(immediate\)](#): Floating-point multiply by immediate (predicated).

[FMUL \(indexed\)](#): Floating-point multiply by indexed elements.

[FMUL \(vectors, predicated\)](#): Floating-point multiply vectors (predicated).

[FMUL \(vectors, unpredicated\)](#): Floating-point multiply vectors (unpredicated).

[FMULX](#): Floating-point multiply-extended vectors (predicated).

[FNEG](#): Floating-point negate (predicated).

[FNMAD](#): Floating-point negated fused multiply-add vectors (predicated), writing multiplicand [ $Z_{dn} = -Z_a + -Z_{dn} * Z_m$ ].

[FNMLA](#): Floating-point negated fused multiply-add vectors (predicated), writing addend [ $Z_{da} = -Z_{da} + -Z_n * Z_m$ ].

[FNMLS](#): Floating-point negated fused multiply-subtract vectors (predicated), writing addend [ $Z_{da} = -Z_{da} + Z_n * Z_m$ ].

[FNMSB](#): Floating-point negated fused multiply-subtract vectors (predicated), writing multiplicand [ $Z_{dn} = -Z_a + Z_{dn} * Z_m$ ].

[FRECPE](#): Floating-point reciprocal estimate (unpredicated).

[FRECPS](#): Floating-point reciprocal step (unpredicated).

[FRECPX](#): Floating-point reciprocal exponent (predicated).

[FRINT<r>](#): Floating-point round to integral value (predicated).

[FRSQRT](#): Floating-point reciprocal square root estimate (unpredicated).

[FRSQRTS](#): Floating-point reciprocal square root step (unpredicated).

[FSCALE](#): Floating-point adjust exponent by vector (predicated).

[FSQRT](#): Floating-point square root (predicated).

[FSUB \(immediate\)](#): Floating-point subtract immediate (predicated).

[FSUB \(vectors, predicated\)](#): Floating-point subtract vectors (predicated).

[FSUB \(vectors, unpredicated\)](#): Floating-point subtract vectors (unpredicated).

[FSUBR \(immediate\)](#): Floating-point reversed subtract from immediate (predicated).

[FSUBR \(vectors\)](#): Floating-point reversed subtract vectors (predicated).

[FTMAD](#): Floating-point trigonometric multiply-add coefficient.

[FTSMUL](#): Floating-point trigonometric starting value.

[FTSSEL](#): Floating-point trigonometric select coefficient.

[INCB, INCD, INCH, INCW \(scalar\)](#): Increment scalar by multiple of predicate constraint element count.

[INCD, INCH, INCW \(vector\)](#): Increment vector by multiple of predicate constraint element count.

[INCP \(scalar\)](#): Increment scalar by count of true predicate elements.

[INCP \(vector\)](#): Increment vector by count of true predicate elements.

[INDEX \(immediate, scalar\)](#): Create index starting from immediate and incremented by general-purpose register.

[INDEX \(immediates\)](#): Create index starting from and incremented by immediate.

[INDEX \(scalar, immediate\)](#): Create index starting from general-purpose register and incremented by immediate.

[INDEX \(scalars\)](#): Create index starting from and incremented by general-purpose register.

[INSR \(scalar\)](#): Insert general-purpose register in shifted vector.

[INSR \(SIMD&FP scalar\)](#): Insert SIMD&FP scalar register in shifted vector.

[LASTA \(scalar\)](#): Extract element after last to general-purpose register.

[LASTA \(SIMD&FP scalar\)](#): Extract element after last to SIMD&FP scalar register.

[LASTB \(scalar\)](#): Extract last element to general-purpose register.

[LASTB \(SIMD&FP scalar\)](#): Extract last element to SIMD&FP scalar register.

[LD1B \(scalar plus immediate\)](#): Contiguous load unsigned bytes to vector (immediate index).

[LD1B \(scalar plus scalar\)](#): Contiguous load unsigned bytes to vector (scalar index).

[LD1B \(scalar plus vector\)](#): Gather load unsigned bytes to vector (vector index).

[LD1B \(vector plus immediate\)](#): Gather load unsigned bytes to vector (immediate index).

[LD1D \(scalar plus immediate\)](#): Contiguous load doublewords to vector (immediate index).

[LD1D \(scalar plus scalar\)](#): Contiguous load doublewords to vector (scalar index).

[LD1D \(scalar plus vector\)](#): Gather load doublewords to vector (vector index).

[LD1D \(vector plus immediate\)](#): Gather load doublewords to vector (immediate index).

[LD1H \(scalar plus immediate\)](#): Contiguous load unsigned halfwords to vector (immediate index).

[LD1H \(scalar plus scalar\)](#): Contiguous load unsigned halfwords to vector (scalar index).

[LD1H \(scalar plus vector\)](#): Gather load unsigned halfwords to vector (vector index).

[LD1H \(vector plus immediate\)](#): Gather load unsigned halfwords to vector (immediate index).

[LD1RB](#): Load and broadcast unsigned byte to vector.

[LD1RD](#): Load and broadcast doubleword to vector.

[LD1RH](#): Load and broadcast unsigned halfword to vector.

[LD1ROB \(scalar plus immediate\)](#): Contiguous load and replicate thirty-two bytes (immediate index).

[LD1ROB \(scalar plus scalar\)](#): Contiguous load and replicate thirty-two bytes (scalar index).

[LD1ROD \(scalar plus immediate\)](#): Contiguous load and replicate four doublewords (immediate index).

[LD1ROD \(scalar plus scalar\)](#): Contiguous load and replicate four doublewords (scalar index).

[LD1ROH \(scalar plus immediate\)](#): Contiguous load and replicate sixteen halfwords (immediate index).

[LD1ROH \(scalar plus scalar\)](#): Contiguous load and replicate sixteen halfwords (scalar index).

[LD1ROW \(scalar plus immediate\)](#): Contiguous load and replicate eight words (immediate index).

[LD1ROW \(scalar plus scalar\)](#): Contiguous load and replicate eight words (scalar index).

[LD1RQB \(scalar plus immediate\)](#): Contiguous load and replicate sixteen bytes (immediate index).

[LD1RQB \(scalar plus scalar\)](#): Contiguous load and replicate sixteen bytes (scalar index).

[LD1RQD \(scalar plus immediate\)](#): Contiguous load and replicate two doublewords (immediate index).

[LD1RQD \(scalar plus scalar\)](#): Contiguous load and replicate two doublewords (scalar index).

[LD1RQH \(scalar plus immediate\)](#): Contiguous load and replicate eight halfwords (immediate index).

[LD1ROH \(scalar plus scalar\)](#): Contiguous load and replicate eight halfwords (scalar index).

[LD1RQW \(scalar plus immediate\)](#): Contiguous load and replicate four words (immediate index).

[LD1RQW \(scalar plus scalar\)](#): Contiguous load and replicate four words (scalar index).

[LD1RSB](#): Load and broadcast signed byte to vector.

[LD1RSH](#): Load and broadcast signed halfword to vector.

[LD1RSW](#): Load and broadcast signed word to vector.

[LD1RW](#): Load and broadcast unsigned word to vector.

[LD1SB \(scalar plus immediate\)](#): Contiguous load signed bytes to vector (immediate index).

[LD1SB \(scalar plus scalar\)](#): Contiguous load signed bytes to vector (scalar index).

[LD1SB \(scalar plus vector\)](#): Gather load signed bytes to vector (vector index).

[LD1SB \(vector plus immediate\)](#): Gather load signed bytes to vector (immediate index).

[LD1SH \(scalar plus immediate\)](#): Contiguous load signed halfwords to vector (immediate index).

[LD1SH \(scalar plus scalar\)](#): Contiguous load signed halfwords to vector (scalar index).

[LD1SH \(scalar plus vector\)](#): Gather load signed halfwords to vector (vector index).

[LD1SH \(vector plus immediate\)](#): Gather load signed halfwords to vector (immediate index).

[LD1SW \(scalar plus immediate\)](#): Contiguous load signed words to vector (immediate index).

[LD1SW \(scalar plus scalar\)](#): Contiguous load signed words to vector (scalar index).

[LD1SW \(scalar plus vector\)](#): Gather load signed words to vector (vector index).



[LD1SW \(vector plus immediate\)](#): Gather load signed words to vector (immediate index).

[LD1W \(scalar plus immediate\)](#): Contiguous load unsigned words to vector (immediate index).

[LD1W \(scalar plus scalar\)](#): Contiguous load unsigned words to vector (scalar index).

[LD1W \(scalar plus vector\)](#): Gather load unsigned words to vector (vector index).

[LD1W \(vector plus immediate\)](#): Gather load unsigned words to vector (immediate index).

[LD2B \(scalar plus immediate\)](#): Contiguous load two-byte structures to two vectors (immediate index).

[LD2B \(scalar plus scalar\)](#): Contiguous load two-byte structures to two vectors (scalar index).

[LD2D \(scalar plus immediate\)](#): Contiguous load two-doubleword structures to two vectors (immediate index).

[LD2D \(scalar plus scalar\)](#): Contiguous load two-doubleword structures to two vectors (scalar index).

[LD2H \(scalar plus immediate\)](#): Contiguous load two-halfword structures to two vectors (immediate index).

[LD2H \(scalar plus scalar\)](#): Contiguous load two-halfword structures to two vectors (scalar index).

[LD2W \(scalar plus immediate\)](#): Contiguous load two-word structures to two vectors (immediate index).

[LD2W \(scalar plus scalar\)](#): Contiguous load two-word structures to two vectors (scalar index).

[LD3B \(scalar plus immediate\)](#): Contiguous load three-byte structures to three vectors (immediate index).

[LD3B \(scalar plus scalar\)](#): Contiguous load three-byte structures to three vectors (scalar index).

[LD3D \(scalar plus immediate\)](#): Contiguous load three-doubleword structures to three vectors (immediate index).

[LD3D \(scalar plus scalar\)](#): Contiguous load three-doubleword structures to three vectors (scalar index).

[LD3H \(scalar plus immediate\)](#): Contiguous load three-halfword structures to three vectors (immediate index).

[LD3H \(scalar plus scalar\)](#): Contiguous load three-halfword structures to three vectors (scalar index).

[LD3W \(scalar plus immediate\)](#): Contiguous load three-word structures to three vectors (immediate index).

[LD3W \(scalar plus scalar\)](#): Contiguous load three-word structures to three vectors (scalar index).

[LD4B \(scalar plus immediate\)](#): Contiguous load four-byte structures to four vectors (immediate index).

[LD4B \(scalar plus scalar\)](#): Contiguous load four-byte structures to four vectors (scalar index).

[LD4D \(scalar plus immediate\)](#): Contiguous load four-doubleword structures to four vectors (immediate index).

[LD4D \(scalar plus scalar\)](#): Contiguous load four-doubleword structures to four vectors (scalar index).

[LD4H \(scalar plus immediate\)](#): Contiguous load four-halfword structures to four vectors (immediate index).

[LD4H \(scalar plus scalar\)](#): Contiguous load four-halfword structures to four vectors (scalar index).

[LD4W \(scalar plus immediate\)](#): Contiguous load four-word structures to four vectors (immediate index).

[LD4W \(scalar plus scalar\)](#): Contiguous load four-word structures to four vectors (scalar index).

[LDFF1B \(scalar plus scalar\)](#): Contiguous load first-fault unsigned bytes to vector (scalar index).

[LDFF1B \(scalar plus vector\)](#): Gather load first-fault unsigned bytes to vector (vector index).

[LDFF1B \(vector plus immediate\)](#): Gather load first-fault unsigned bytes to vector (immediate index).

[LDFF1D \(scalar plus scalar\)](#): Contiguous load first-fault doublewords to vector (scalar index).

[LDFF1D \(scalar plus vector\)](#): Gather load first-fault doublewords to vector (vector index).

[LDFF1D \(vector plus immediate\)](#): Gather load first-fault doublewords to vector (immediate index).

[LDFF1H \(scalar plus scalar\)](#): Contiguous load first-fault unsigned halfwords to vector (scalar index).



[LDFF1H \(scalar plus vector\)](#): Gather load first-fault unsigned halfwords to vector (vector index).

[LDFF1H \(vector plus immediate\)](#): Gather load first-fault unsigned halfwords to vector (immediate index).

[LDFF1SB \(scalar plus scalar\)](#): Contiguous load first-fault signed bytes to vector (scalar index).

[LDFF1SB \(scalar plus vector\)](#): Gather load first-fault signed bytes to vector (vector index).

[LDFF1SB \(vector plus immediate\)](#): Gather load first-fault signed bytes to vector (immediate index).

[LDFF1SH \(scalar plus scalar\)](#): Contiguous load first-fault signed halfwords to vector (scalar index).

[LDFF1SH \(scalar plus vector\)](#): Gather load first-fault signed halfwords to vector (vector index).

[LDFF1SH \(vector plus immediate\)](#): Gather load first-fault signed halfwords to vector (immediate index).

[LDFF1SW \(scalar plus scalar\)](#): Contiguous load first-fault signed words to vector (scalar index).

[LDFF1SW \(scalar plus vector\)](#): Gather load first-fault signed words to vector (vector index).

[LDFF1SW \(vector plus immediate\)](#): Gather load first-fault signed words to vector (immediate index).

[LDFF1W \(scalar plus scalar\)](#): Contiguous load first-fault unsigned words to vector (scalar index).

[LDFF1W \(scalar plus vector\)](#): Gather load first-fault unsigned words to vector (vector index).

[LDFF1W \(vector plus immediate\)](#): Gather load first-fault unsigned words to vector (immediate index).

[LDNF1B](#): Contiguous load non-fault unsigned bytes to vector (immediate index).

[LDNF1D](#): Contiguous load non-fault doublewords to vector (immediate index).

[LDNF1H](#): Contiguous load non-fault unsigned halfwords to vector (immediate index).

[LDNF1SB](#): Contiguous load non-fault signed bytes to vector (immediate index).

[LDNF1SH](#): Contiguous load non-fault signed halfwords to vector (immediate index).

[LDNF1SW](#): Contiguous load non-fault signed words to vector (immediate index).

[LDNF1W](#): Contiguous load non-fault unsigned words to vector (immediate index).

[LDNT1B \(scalar plus immediate\)](#): Contiguous load non-temporal bytes to vector (immediate index).

[LDNT1B \(scalar plus scalar\)](#): Contiguous load non-temporal bytes to vector (scalar index).

[LDNT1D \(scalar plus immediate\)](#): Contiguous load non-temporal doublewords to vector (immediate index).

[LDNT1D \(scalar plus scalar\)](#): Contiguous load non-temporal doublewords to vector (scalar index).

[LDNT1H \(scalar plus immediate\)](#): Contiguous load non-temporal halfwords to vector (immediate index).

[LDNT1H \(scalar plus scalar\)](#): Contiguous load non-temporal halfwords to vector (scalar index).

[LDNT1W \(scalar plus immediate\)](#): Contiguous load non-temporal words to vector (immediate index).

[LDNT1W \(scalar plus scalar\)](#): Contiguous load non-temporal words to vector (scalar index).

[LDR \(predicate\)](#): Load predicate register.

[LDR \(vector\)](#): Load vector register.

[LSL \(immediate, predicated\)](#): Logical shift left by immediate (predicated).

[LSL \(immediate, unpredicated\)](#): Logical shift left by immediate (unpredicated).

[LSL \(vectors\)](#): Logical shift left by vector (predicated).

[LSL \(wide elements, predicated\)](#): Logical shift left by 64-bit wide elements (predicated).

[LSL \(wide elements, unpredicated\)](#): Logical shift left by 64-bit wide elements (unpredicated).

[LSLR](#): Reversed logical shift left by vector (predicated).

[LSR \(immediate, predicated\)](#): Logical shift right by immediate (predicated).

[LSR \(immediate, unpredicated\)](#): Logical shift right by immediate (unpredicated).

[LSR \(vectors\)](#): Logical shift right by vector (predicated).

[LSR \(wide elements, predicated\)](#): Logical shift right by 64-bit wide elements (predicated).

[LSR \(wide elements, unpredicated\)](#): Logical shift right by 64-bit wide elements (unpredicated).

[LSRR](#): Reversed logical shift right by vector (predicated).

[MAD](#): Multiply-add vectors (predicated), writing multiplicand [ $Z_{dn} = Z_a + Z_{dn} * Z_m$ ].

[MLA](#): Multiply-add vectors (predicated), writing addend [ $Z_{da} = Z_{da} + Z_n * Z_m$ ].

[MLS](#): Multiply-subtract vectors (predicated), writing addend [ $Z_{da} = Z_{da} - Z_n * Z_m$ ].

[MOV \(bitmask immediate\)](#): Move logical bitmask immediate to vector (unpredicated): an alias of DUPM.

[MOV \(immediate, predicated, merging\)](#): Move signed integer immediate to vector elements (merging): an alias of CPY (immediate, merging).

[MOV \(immediate, predicated, zeroing\)](#): Move signed integer immediate to vector elements (zeroing): an alias of CPY (immediate, zeroing).

[MOV \(immediate, unpredicated\)](#): Move signed immediate to vector elements (unpredicated): an alias of DUP (immediate).

[MOV \(predicate, predicated, merging\)](#): Move predicates (merging): an alias of SEL (predicates).

[MOV \(predicate, predicated, zeroing\)](#): Move predicates (zeroing): an alias of AND, ANDS (predicates).

[MOV \(predicate, unpredicated\)](#): Move predicate (unpredicated): an alias of ORR, ORRS (predicates).

[MOV \(scalar, predicated\)](#): Move general-purpose register to vector elements (predicated): an alias of CPY (scalar).

[MOV \(scalar, unpredicated\)](#): Move general-purpose register to vector elements (unpredicated): an alias of DUP (scalar).

[MOV \(SIMD&FP scalar, predicated\)](#): Move SIMD&FP scalar register to vector elements (predicated): an alias of CPY (SIMD&FP scalar).

[MOV \(SIMD&FP scalar, unpredicated\)](#): Move indexed element or SIMD&FP scalar to vector (unpredicated): an alias of DUP (indexed).

[MOV \(vector, predicated\)](#): Move vector elements (predicated): an alias of SEL (vectors).

[MOV \(vector, unpredicated\)](#): Move vector register (unpredicated): an alias of ORR (vectors, unpredicated).

[MOVPRFX \(predicated\)](#): Move prefix (predicated).

[MOVPRFX \(unpredicated\)](#): Move prefix (unpredicated).

[MOVS \(predicated\)](#): Move predicates (zeroing), setting the condition flags: an alias of AND, ANDS (predicates).

[MOVS \(unpredicated\)](#): Move predicate (unpredicated), setting the condition flags: an alias of ORR, ORRS (predicates).

[MSB](#): Multiply-subtract vectors (predicated), writing multiplicand [ $Z_{dn} = Z_a - Z_{dn} * Z_m$ ].

[MUL \(immediate\)](#): Multiply by immediate (unpredicated).

[MUL \(vectors\)](#): Multiply vectors (predicated).

[NAND, NANDS](#): Bitwise NAND predicates.

[NEG](#): Negate (predicated).

[NOR, NORs](#): Bitwise NOR predicates.

[NOT \(predicate\)](#): Bitwise invert predicate: an alias of EOR, EORS (predicates).

[NOT \(vector\)](#): Bitwise invert vector (predicated).

[NOTS](#): Bitwise invert predicate, setting the condition flags: an alias of EOR, EORS (predicates).

[ORN \(immediate\)](#): Bitwise inclusive OR with inverted immediate (unpredicated): an alias of ORR (immediate).

[ORN, ORNS \(predicates\)](#): Bitwise inclusive OR inverted predicate.

[ORR \(immediate\)](#): Bitwise inclusive OR with immediate (unpredicated).

[ORR \(vectors, predicated\)](#): Bitwise inclusive OR vectors (predicated).

[ORR \(vectors, unpredicated\)](#): Bitwise inclusive OR vectors (unpredicated).

[ORR, ORRS \(predicates\)](#): Bitwise inclusive OR predicate.

[ORV](#): Bitwise inclusive OR reduction to scalar.

[PFALSE](#): Set all predicate elements to false.

[PFIRST](#): Set the first active predicate element to true.

[PNEXT](#): Find next active predicate.

[PRFB \(scalar plus immediate\)](#): Contiguous prefetch bytes (immediate index).

[PRFB \(scalar plus scalar\)](#): Contiguous prefetch bytes (scalar index).

[PRFB \(scalar plus vector\)](#): Gather prefetch bytes (scalar plus vector).

[PRFB \(vector plus immediate\)](#): Gather prefetch bytes (vector plus immediate).

[PRFD \(scalar plus immediate\)](#): Contiguous prefetch doublewords (immediate index).

[PRFD \(scalar plus scalar\)](#): Contiguous prefetch doublewords (scalar index).

[PRFD \(scalar plus vector\)](#): Gather prefetch doublewords (scalar plus vector).

[PRFD \(vector plus immediate\)](#): Gather prefetch doublewords (vector plus immediate).

[PRFH \(scalar plus immediate\)](#): Contiguous prefetch halfwords (immediate index).

[PRFH \(scalar plus scalar\)](#): Contiguous prefetch halfwords (scalar index).

[PRFH \(scalar plus vector\)](#): Gather prefetch halfwords (scalar plus vector).

[PRFH \(vector plus immediate\)](#): Gather prefetch halfwords (vector plus immediate).

[PRFW \(scalar plus immediate\)](#): Contiguous prefetch words (immediate index).

[PRFW \(scalar plus scalar\)](#): Contiguous prefetch words (scalar index).

[PRFW \(scalar plus vector\)](#): Gather prefetch words (scalar plus vector).

[PRFW \(vector plus immediate\)](#): Gather prefetch words (vector plus immediate).

[PTEST](#): Set condition flags for predicate.

[PTRUE, PTRUES](#): Initialise predicate from named constraint.

[PUNPKHL, PUNPKLO](#): Unpack and widen half of predicate.

[RBIT](#): Reverse bits (predicated).

[RDFFR \(unpredicated\)](#): Read the first-fault register.

[RDFFR, RDFFRS \(predicated\)](#): Return predicate of successfully loaded elements.

[RDVL](#): Read multiple of vector register size to scalar register.

[REV \(predicate\)](#): Reverse all elements in a predicate.

[REV \(vector\)](#): Reverse all elements in a vector (unpredicated).

[REVB, REVH, REVW](#): Reverse bytes / halfwords / words within elements (predicated).

[SABD](#): Signed absolute difference (predicated).

[SADDV](#): Signed add reduction to scalar.

[SCVTF](#): Signed integer convert to floating-point (predicated).

[SDIV](#): Signed divide (predicated).

[SDIVR](#): Signed reversed divide (predicated).

[SDOT \(indexed\)](#): Signed integer indexed dot product.

[SDOT \(vectors\)](#): Signed integer dot product.

[SEL \(predicates\)](#): Conditionally select elements from two predicates.

[SEL \(vectors\)](#): Conditionally select elements from two vectors.

[SETFFR](#): Initialise the first-fault register to all true.

[SMAX \(immediate\)](#): Signed maximum with immediate (unpredicated).

[SMAX \(vectors\)](#): Signed maximum vectors (predicated).

[SMA XV](#): Signed maximum reduction to scalar.

[SMIN \(immediate\)](#): Signed minimum with immediate (unpredicated).

[SMIN \(vectors\)](#): Signed minimum vectors (predicated).

[SMINV](#): Signed minimum reduction to scalar.

[SMMLA](#): Signed integer matrix multiply-accumulate.

[SMULH](#): Signed multiply returning high half (predicated).

[SPLICE](#): Splice two vectors under predicate control.

[SQADD \(immediate\)](#): Signed saturating add immediate (unpredicated).

[SQADD \(vectors\)](#): Signed saturating add vectors (unpredicated).

[SQDECB](#): Signed saturating decrement scalar by multiple of 8-bit predicate constraint element count.

[SQDECD \(scalar\)](#): Signed saturating decrement scalar by multiple of 64-bit predicate constraint element count.

[SQDECD \(vector\)](#): Signed saturating decrement vector by multiple of 64-bit predicate constraint element count.

[SQDECH \(scalar\)](#): Signed saturating decrement scalar by multiple of 16-bit predicate constraint element count.

[SQDECH \(vector\)](#): Signed saturating decrement vector by multiple of 16-bit predicate constraint element count.

[SQDECP \(scalar\)](#): Signed saturating decrement scalar by count of true predicate elements.

[SQDECP \(vector\)](#): Signed saturating decrement vector by count of true predicate elements.

[SQDECW \(scalar\)](#): Signed saturating decrement scalar by multiple of 32-bit predicate constraint element count.

[SQDECW \(vector\)](#): Signed saturating decrement vector by multiple of 32-bit predicate constraint element count.

[SQINCB](#): Signed saturating increment scalar by multiple of 8-bit predicate constraint element count.

[SQINCD \(scalar\)](#): Signed saturating increment scalar by multiple of 64-bit predicate constraint element count.

[SQINCD \(vector\)](#): Signed saturating increment vector by multiple of 64-bit predicate constraint element count.

[SQINCH \(scalar\)](#): Signed saturating increment scalar by multiple of 16-bit predicate constraint element count.

[SQINCH \(vector\)](#): Signed saturating increment vector by multiple of 16-bit predicate constraint element count.

[SQINCP \(scalar\)](#): Signed saturating increment scalar by count of true predicate elements.

[SQINCP \(vector\)](#): Signed saturating increment vector by count of true predicate elements.

[SQINCW \(scalar\)](#): Signed saturating increment scalar by multiple of 32-bit predicate constraint element count.

[SQINCW \(vector\)](#): Signed saturating increment vector by multiple of 32-bit predicate constraint element count.

[SQSUB \(immediate\)](#): Signed saturating subtract immediate (unpredicated).

[SQSUB \(vectors\)](#): Signed saturating subtract vectors (unpredicated).

[ST1B \(scalar plus immediate\)](#): Contiguous store bytes from vector (immediate index).

[ST1B \(scalar plus scalar\)](#): Contiguous store bytes from vector (scalar index).

[ST1B \(scalar plus vector\)](#): Scatter store bytes from a vector (vector index).

[ST1B \(vector plus immediate\)](#): Scatter store bytes from a vector (immediate index).

[ST1D \(scalar plus immediate\)](#): Contiguous store doublewords from vector (immediate index).

[ST1D \(scalar plus scalar\)](#): Contiguous store doublewords from vector (scalar index).

[ST1D \(scalar plus vector\)](#): Scatter store doublewords from a vector (vector index).

[ST1D \(vector plus immediate\)](#): Scatter store doublewords from a vector (immediate index).

[ST1H \(scalar plus immediate\)](#): Contiguous store halfwords from vector (immediate index).

[ST1H \(scalar plus scalar\)](#): Contiguous store halfwords from vector (scalar index).

[ST1H \(scalar plus vector\)](#): Scatter store halfwords from a vector (vector index).

[ST1H \(vector plus immediate\)](#): Scatter store halfwords from a vector (immediate index).

[ST1W \(scalar plus immediate\)](#): Contiguous store words from vector (immediate index).

[ST1W \(scalar plus scalar\)](#): Contiguous store words from vector (scalar index).

[ST1W \(scalar plus vector\)](#): Scatter store words from a vector (vector index).

[ST1W \(vector plus immediate\)](#): Scatter store words from a vector (immediate index).

[ST2B \(scalar plus immediate\)](#): Contiguous store two-byte structures from two vectors (immediate index).

[ST2B \(scalar plus scalar\)](#): Contiguous store two-byte structures from two vectors (scalar index).

[ST2D \(scalar plus immediate\)](#): Contiguous store two-doubleword structures from two vectors (immediate index).

[ST2D \(scalar plus scalar\)](#): Contiguous store two-doubleword structures from two vectors (scalar index).

[ST2H \(scalar plus immediate\)](#): Contiguous store two-halfword structures from two vectors (immediate index).

[ST2H \(scalar plus scalar\)](#): Contiguous store two-halfword structures from two vectors (scalar index).

[ST2W \(scalar plus immediate\)](#): Contiguous store two-word structures from two vectors (immediate index).

[ST2W \(scalar plus scalar\)](#): Contiguous store two-word structures from two vectors (scalar index).

[ST3B \(scalar plus immediate\)](#): Contiguous store three-byte structures from three vectors (immediate index).

[ST3B \(scalar plus scalar\)](#): Contiguous store three-byte structures from three vectors (scalar index).

[ST3D \(scalar plus immediate\)](#): Contiguous store three-doubleword structures from three vectors (immediate index).

[ST3D \(scalar plus scalar\)](#): Contiguous store three-doubleword structures from three vectors (scalar index).

[ST3H \(scalar plus immediate\)](#): Contiguous store three-halfword structures from three vectors (immediate index).

[ST3H \(scalar plus scalar\)](#): Contiguous store three-halfword structures from three vectors (scalar index).

[ST3W \(scalar plus immediate\)](#): Contiguous store three-word structures from three vectors (immediate index).

[ST3W \(scalar plus scalar\)](#): Contiguous store three-word structures from three vectors (scalar index).

[ST4B \(scalar plus immediate\)](#): Contiguous store four-byte structures from four vectors (immediate index).

[ST4B \(scalar plus scalar\)](#): Contiguous store four-byte structures from four vectors (scalar index).

[ST4D \(scalar plus immediate\)](#): Contiguous store four-doubleword structures from four vectors (immediate index).

[ST4D \(scalar plus scalar\)](#): Contiguous store four-doubleword structures from four vectors (scalar index).

[ST4H \(scalar plus immediate\)](#): Contiguous store four-halfword structures from four vectors (immediate index).

[ST4H \(scalar plus scalar\)](#): Contiguous store four-halfword structures from four vectors (scalar index).

[ST4W \(scalar plus immediate\)](#): Contiguous store four-word structures from four vectors (immediate index).

[ST4W \(scalar plus scalar\)](#): Contiguous store four-word structures from four vectors (scalar index).

[STNT1B \(scalar plus immediate\)](#): Contiguous store non-temporal bytes from vector (immediate index).

[STNT1B \(scalar plus scalar\)](#): Contiguous store non-temporal bytes from vector (scalar index).

[STNT1D \(scalar plus immediate\)](#): Contiguous store non-temporal doublewords from vector (immediate index).

[STNT1D \(scalar plus scalar\)](#): Contiguous store non-temporal doublewords from vector (scalar index).

[STNT1H \(scalar plus immediate\)](#): Contiguous store non-temporal halfwords from vector (immediate index).

[STNT1H \(scalar plus scalar\)](#): Contiguous store non-temporal halfwords from vector (scalar index).

[STNT1W \(scalar plus immediate\)](#): Contiguous store non-temporal words from vector (immediate index).

[STNT1W \(scalar plus scalar\)](#): Contiguous store non-temporal words from vector (scalar index).

[STR \(predicate\)](#): Store predicate register.

[STR \(vector\)](#): Store vector register.

[SUB \(immediate\)](#): Subtract immediate (unpredicated).

[SUB \(vectors, predicated\)](#): Subtract vectors (predicated).

[SUB \(vectors, unpredicated\)](#): Subtract vectors (unpredicated).

[SUBR \(immediate\)](#): Reversed subtract from immediate (unpredicated).

[SUBR \(vectors\)](#): Reversed subtract vectors (predicated).

[SUDOT](#): Signed by unsigned integer indexed dot product.

[SUNPKHL, SUNPKLO](#): Signed unpack and extend half of vector.

[SXTB, SXTH, SXTW](#): Signed byte / halfword / word extend (predicated).

[TBL](#): Programmable table lookup in single vector table.

[TRN1, TRN2 \(predicates\)](#): Interleave even or odd elements from two predicates.

[TRN1, TRN2 \(vectors\)](#): Interleave even or odd elements from two vectors.

[UABD](#): Unsigned absolute difference (predicated).

[UADDV](#): Unsigned add reduction to scalar.

[UCVTF](#): Unsigned integer convert to floating-point (predicated).



[UDIV](#): Unsigned divide (predicated).

[UDIVR](#): Unsigned reversed divide (predicated).

[UDOT \(indexed\)](#): Unsigned integer indexed dot product.

[UDOT \(vectors\)](#): Unsigned integer dot product.

[UMAX \(immediate\)](#): Unsigned maximum with immediate (unpredicated).

[UMAX \(vectors\)](#): Unsigned maximum vectors (predicated).

[UMAXV](#): Unsigned maximum reduction to scalar.

[UMIN \(immediate\)](#): Unsigned minimum with immediate (unpredicated).

[UMIN \(vectors\)](#): Unsigned minimum vectors (predicated).

[UMINV](#): Unsigned minimum reduction to scalar.

[UMMLA](#): Unsigned integer matrix multiply-accumulate.

[UMULH](#): Unsigned multiply returning high half (predicated).

[UQADD \(immediate\)](#): Unsigned saturating add immediate (unpredicated).

[UQADD \(vectors\)](#): Unsigned saturating add vectors (unpredicated).

[UQDECB](#): Unsigned saturating decrement scalar by multiple of 8-bit predicate constraint element count.

[UQDECD \(scalar\)](#): Unsigned saturating decrement scalar by multiple of 64-bit predicate constraint element count.

[UQDECD \(vector\)](#): Unsigned saturating decrement vector by multiple of 64-bit predicate constraint element count.

[UQDECH \(scalar\)](#): Unsigned saturating decrement scalar by multiple of 16-bit predicate constraint element count.

[UQDECH \(vector\)](#): Unsigned saturating decrement vector by multiple of 16-bit predicate constraint element count.

[UQDECP \(scalar\)](#): Unsigned saturating decrement scalar by count of true predicate elements.

[UQDECP \(vector\)](#): Unsigned saturating decrement vector by count of true predicate elements.

[UQDECW \(scalar\)](#): Unsigned saturating decrement scalar by multiple of 32-bit predicate constraint element count.

[UQDECW \(vector\)](#): Unsigned saturating decrement vector by multiple of 32-bit predicate constraint element count.

[UQINCB](#): Unsigned saturating increment scalar by multiple of 8-bit predicate constraint element count.

[UQINCD \(scalar\)](#): Unsigned saturating increment scalar by multiple of 64-bit predicate constraint element count.

[UQINCD \(vector\)](#): Unsigned saturating increment vector by multiple of 64-bit predicate constraint element count.

[UQINCH \(scalar\)](#): Unsigned saturating increment scalar by multiple of 16-bit predicate constraint element count.

[UQINCH \(vector\)](#): Unsigned saturating increment vector by multiple of 16-bit predicate constraint element count.

[UQINCP \(scalar\)](#): Unsigned saturating increment scalar by count of true predicate elements.

[UQINCP \(vector\)](#): Unsigned saturating increment vector by count of true predicate elements.

[UQINCW \(scalar\)](#): Unsigned saturating increment scalar by multiple of 32-bit predicate constraint element count.

[UQINCW \(vector\)](#): Unsigned saturating increment vector by multiple of 32-bit predicate constraint element count.

[UQSUB \(immediate\)](#): Unsigned saturating subtract immediate (unpredicated).

[UQSUB \(vectors\)](#): Unsigned saturating subtract vectors (unpredicated).

[USDOT \(indexed\)](#): Unsigned by signed integer indexed dot product.

[USDOT \(vectors\)](#): Unsigned by signed integer dot product.

[USMMLA](#): Unsigned by signed integer matrix multiply-accumulate.

[UUNPKHL](#), [UUNPKLO](#): Unsigned unpack and extend half of vector.

[UXTB](#), [UXTH](#), [UXTW](#): Unsigned byte / halfword / word extend (predicated).

[UZP1](#), [UZP2 \(predicates\)](#): Concatenate even or odd elements from two predicates.

[UZP1](#), [UZP2 \(vectors\)](#): Concatenate even or odd elements from two vectors.

[WHILELE](#): While incrementing signed scalar less than or equal to scalar.

[WHILELO](#): While incrementing unsigned scalar lower than scalar.

[WHILELS](#): While incrementing unsigned scalar lower or same as scalar.

[WHILELT](#): While incrementing signed scalar less than scalar.

[WRFFR](#): Write the first-fault register.

[ZIP1](#), [ZIP2 \(predicates\)](#): Interleave elements from two half predicates.

[ZIP1](#), [ZIP2 \(vectors\)](#): Interleave elements from two half vectors.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# ABS

Absolute value (predicated)

Compute the absolute value of the signed integer in each active element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	0	1	1	0	1	0	1	Pg			Zn			Zd							

ABS <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) result = Z[d];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer element = SInt(Elem[operand, e, esize]);
        element = Abs(element);
        Elem[result, e, esize] = element<esize-1:0>;

Z[d] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



# ADD (vectors, predicated)

Add vectors (predicated)

Add active elements of the second source vector to corresponding elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	0	0	0	0	0	0	0	0	0	Pg												

ADD <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = element1 + element2;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



# ADD (immediate)

Add immediate (unpredicated)

Add an unsigned immediate to each element of the source vector, and destructively place the results in the corresponding elements of the source vector. This instruction is unpredicated.

The immediate is an unsigned value in the range 0 to 255, and for element widths of 16 bits or higher it may also be a positive multiple of 256 in the range 256 to 65280.

The immediate is encoded in 8 bits with an optional left shift by 8. The preferred disassembly when the shift option is specified is "#<uimm8>, LSL #8". However an assembler and disassembler may also allow use of the shifted 16-bit value unless the immediate is 0 and the shift amount is 8, which must be unambiguously described as "#0, LSL #8".

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size		1	0	0	0	0	0	1	1	sh	imm8								Zdn				

ADD <Zdn>.<T>, <Zdn>.<T>, #<imm>{, <shift>}

```
if !HaveSVE() then UNDEFINED;
if size:sh == '001' then UNDEFINED;
integer esize = 8 << UInt(size);
integer dn = UInt(Zdn);
integer imm = UInt(imm8);
if sh == '1' then imm = imm << 8;
```

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<imm> Is an unsigned immediate in the range 0 to 255, encoded in the "imm8" field.

<shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #8

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    Elem[result, e, esize] = element1 + imm;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# ADD (vectors, unpredicated)

Add vectors (unpredicated)

Add all elements of the second source vector to corresponding elements of the first source vector and place the results in the corresponding elements of the destination vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	0	0	0	0	1	0	0	size	1	Zm						0	0	0	0	0	0	Zn						Zd					

ADD <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = element1 + element2;

Z[d] = result;
```

# ADDPL

Add multiple of predicate register size to scalar register

Add the current predicate register size in bytes multiplied by an immediate in the range -32 to 31 to the 64-bit source general-purpose register or current stack pointer and place the result in the 64-bit destination general-purpose register or current stack pointer.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1	Rn				0	1	0	1	0	imm6						Rd					

ADDPL <Xd|SP>, <Xn|SP>, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer n = UInt(Rn);
integer d = UInt(Rd);
integer imm = SInt(imm6);
```

## Assembler Symbols

- <Xd|SP> Is the 64-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Xn|SP> Is the 64-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.
- <imm> Is the signed immediate operand, in the range -32 to 31, encoded in the "imm6" field.

## Operation

```
CheckSVEEnabled();
bits(64) operand1 = if n == 31 then SP[] else X[n];
bits(64) result = operand1 + (imm * (PL DIV 8));

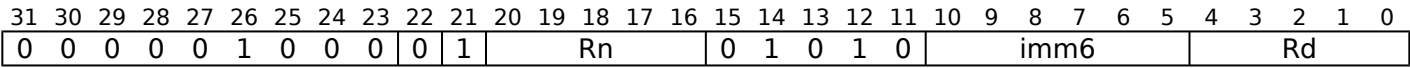
if d == 31 then
    SP[] = result;
else
    X[d] = result;
```



# ADDVL

Add multiple of vector register size to scalar register

Add the current vector register size in bytes multiplied by an immediate in the range -32 to 31 to the 64-bit source general-purpose register or current stack pointer, and place the result in the 64-bit destination general-purpose register or current stack pointer.



ADDVL <Xd|SP>, <Xn|SP>, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer n = UInt(Rn);
integer d = UInt(Rd);
integer imm = SInt(imm6);
```

## Assembler Symbols

- <Xd|SP> Is the 64-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Xn|SP> Is the 64-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.
- <imm> Is the signed immediate operand, in the range -32 to 31, encoded in the "imm6" field.

## Operation

```
CheckSVEEnabled();
bits(64) operand1 = if n == 31 then SP[] else X[n];
bits(64) result = operand1 + (imm * (VL DIV 8));

if d == 31 then
    SP[] = result;
else
    X[d] = result;
```

## ADR

Compute vector address

Optionally sign or zero-extend the least significant 32-bits of each element from a vector of offsets or indices in the second source vector, scale each index by 2, 4 or 8, add to a vector of base addresses from the first source vector, and place the resulting addresses in the destination vector. This instruction is unpredicated.

It has encodings from 3 classes: [Packed offsets](#) , [Unpacked 32-bit signed offsets](#) and [Unpacked 32-bit unsigned offsets](#)

### Packed offsets

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	sz	1	Zm					1	0	1	0	msz	Zn					Zd					

ADR <Zd>.<T>, [<Zn>.<T>, <Zm>.<T>{, <mod> <amount>}]

```
if !HaveSVE() then UNDEFINED;
integer esize = 32 << UInt(sz);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer osize = esize;
boolean unsigned = TRUE;
integer mbytes = 1 << UInt(msz);
```

### Unpacked 32-bit signed offsets

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	1	Zm					1	0	1	0	msz	Zn					Zd					

ADR <Zd>.D, [<Zn>.D, <Zm>.D, SXTW{ <amount>}]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer osize = 32;
boolean unsigned = FALSE;
integer mbytes = 1 << UInt(msz);
```

### Unpacked 32-bit unsigned offsets

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1	Zm				1	0	1	0	msz	Zn				Zd							

ADR <Zd>.D, [<Zn>.D, <Zm>.D, UXTW{ <amount>}]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer osize = 32;
boolean unsigned = TRUE;
integer mbytes = 1 << UInt(msz);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in “sz”:

sz	<T>
0	S
1	D

<Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.

<mod> Is the index extend and shift specifier, encoded in “msz”:

msz	<mod>
00	[absent]
x1	LSL
10	LSL

<amount> Is the index shift amount, encoded in “msz”:

msz	<amount>
00	[absent]
01	#1
10	#2
11	#3

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(VL) offs = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) addr = Elem[base, e, esize];
    integer offset = Int(Elem[offs, e, esize]<osize-1:0>, unsigned);
    Elem[result, e, esize] = addr + (offset * mbytes);

Z[d] = result;
```

# AND, ANDS (predicates)

Bitwise AND predicates

Bitwise AND active elements of the second source predicate with corresponding elements of the first source predicate and place the results in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Optionally sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

This instruction is used by the aliases [MOVS \(predicated\)](#), and [MOV \(predicate, predicated, zeroing\)](#).

It has encodings from 2 classes: [Not setting the condition flags](#) and [Setting the condition flags](#)

## Not setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	0	0	0	Pm				0	1	Pg				0	Pn				0	Pd			
S																															

AND <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = FALSE;
```

## Setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	1	0	0	Pm				0	1	Pg				0	Pn				0	Pd			
S																															

ANDS <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = TRUE;
```

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.
- <Pm> Is the name of the second source scalable predicate register, encoded in the "Pm" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">MOVS (predicated)</a>	S == '1' && Pn == Pm
<a href="#">MOV (predicate, predicated, zeroing)</a>	S == '0' && Pn == Pm

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(PL) operand1 = P[n];
bits(PL) operand2 = P[m];
bits(PL) result;

for e = 0 to elements-1
    bit element1 = ElemP[operand1, e, esize];
    bit element2 = ElemP[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        ElemP[result, e, esize] = element1 AND element2;
    else
        ElemP[result, e, esize] = '0';

if setflags then
    PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# AND (vectors, predicated)

Bitwise AND vectors (predicated)

Bitwise AND active elements of the second source vector with corresponding elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	0	1	0	0	0	0	Pg	Zm				Zdn								

AND <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = element1 AND element2;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];
Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



# AND (immediate)

Bitwise AND with immediate (unpredicated)

Bitwise AND an immediate with each 64-bit element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate is a 64-bit value consisting of a single run of ones or zeros repeating every 2, 4, 8, 16, 32 or 64 bits. This instruction is unpredicated.

This instruction is used by the pseudo-instruction [BIC \(immediate\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	1	0	0	0	0	0	imm13														Zdn			

AND <Zdn>.<T>, <Zdn>.<T>, #<const>

```
if !HaveSVE() then UNDEFINED;
integer dn = UInt(Zdn);
bits(64) imm;
(imm, -) = DecodeBitMasks(imm13<12>, imm13<5:0>, imm13<11:6>, TRUE);
```

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "imm13<12>:imm13<5:0>":

imm13<12>	imm13<5:0>	<T>
0	0xxxxx	S
0	10xxxx	H
0	110xxx	B
0	1110xx	B
0	11110x	B
0	111110	RESERVED
0	111111	RESERVED
1	xxxxxx	D

<const> Is a 64, 32, 16 or 8-bit bitmask consisting of replicated 2, 4, 8, 16, 32 or 64 bit fields, each field containing a rotated run of non-zero bits, encoded in the "imm13" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV 64;
bits(VL) operand = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    bits(64) element1 = Elem[operand, e, 64];
    Elem[result, e, 64] = element1 AND imm;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.





# AND (vectors, unpredicated)

Bitwise AND vectors (unpredicated)

Bitwise AND all elements of the second source vector with corresponding elements of the first source vector and place the results in the corresponding elements of the destination vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	1	Zm					0	0	1	1	0	0	Zn					Zd				

AND <Zd>.D, <Zn>.D, <Zm>.D

```
if !HaveSVE() then UNDEFINED;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];

Z[d] = operand1 AND operand2;
```

ANDV

Bitwise AND reduction to scalar

Bitwise AND horizontally across all lanes of a vector, and place the result in the SIMD&FP scalar destination register. Inactive elements in the source vector are treated as all ones.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	0	1	0	0	0	1	Pg													

ANDV <V><d>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D

<d> Is the number [0-31] of the destination SIMD&FP register, encoded in the "Vd" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<T> Is the size specifier, encoded in “size”:

size	<T>
00	B
01	H
10	S
11	D

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(esize) result = Ones(esize);

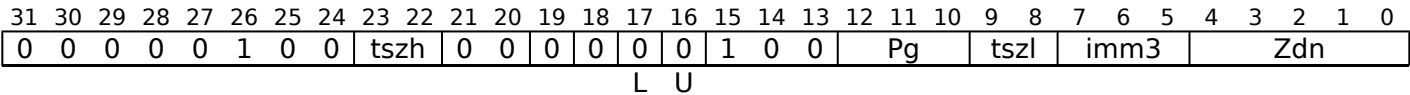
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        result = result AND Elem[operand, e, esize];

V[d] = result;
```

# ASR (immediate, predicated)

Arithmetic shift right by immediate (predicated)

Shift right by immediate, preserving the sign bit, each active element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate shift amount is an unsigned value in the range 1 to number of bits per element. Inactive elements in the destination vector register remain unmodified.



ASR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, #<const>

```
if !HaveSVE() then UNDEFINED;
bits(4) tsize = tszh:tszl;
case tsize of
    when '0000' UNDEFINED;
    when '0001' esize = 8;
    when '001x' esize = 16;
    when '01xx' esize = 32;
    when '1xxx' esize = 64;
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
00	00	RESERVED
00	01	B
00	1x	H
01	xx	S
1x	xx	D
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <const> Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(PL) mask = P[g];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = ASR(element1, shift);
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];
Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

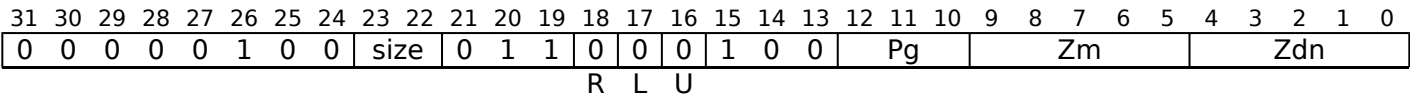
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## ASR (wide elements, predicated)

Arithmetic shift right by 64-bit wide elements (predicated)

Shift right, preserving the sign bit, active elements of the first source vector by corresponding overlapping 64-bit elements of the second source vector and destructively place the results in the corresponding elements of the first source vector. The shift amount is a vector of unsigned 64-bit doubleword elements in which all bits are significant, and not used modulo the destination element size. Inactive elements in the destination vector register remain unmodified.



ASR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.D

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

### Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	RESERVED

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element1 = Elem[operand1, e, esize];
        bits(64) element2 = Elem[operand2, (e * esize) DIV 64, 64];
        integer shift = Min(UInt(element2), esize);
        Elem[result, e, esize] = ASR(element1, shift);
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

### Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and destination element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

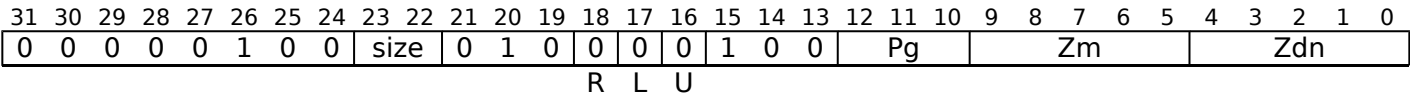
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## ASR (vectors)

Arithmetic shift right by vector (predicated)

Shift right, preserving the sign bit, active elements of the first source vector by corresponding elements of the second source vector and destructively place the results in the corresponding elements of the first source vector. The shift amount operand is a vector of unsigned elements in which all bits are significant, and not used modulo the element size. Inactive elements in the destination vector register remain unmodified.



ASR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

### Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element1 = Elem[operand1, e, esize];
        bits(esize) element2 = Elem[operand2, e, esize];
        integer shift = Min(UInt(element2), esize);
        Elem[result, e, esize] = ASR(element1, shift);
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

### Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:



- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

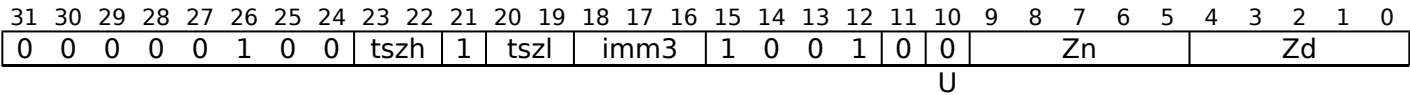
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

ASR (immediate, unpredicated)

Arithmetic shift right by immediate (unpredicated)

Shift right by immediate, preserving the sign bit, each element of the source vector, and place the results in the corresponding elements of the destination vector. The immediate shift amount is an unsigned value in the range 1 to number of bits per element. This instruction is unpredicated.



ASR <Zd>.<T>, <Zn>.<T>, #<const>

```
if !HaveSVE() then UNDEFINED;
bits(4) tsize = tszh:tszl;
case tsize of
  when '0000' UNDEFINED;
  when '0001' esize = 8;
  when '001x' esize = 16;
  when '01xx' esize = 32;
  when '1xxx' esize = 64;
integer n = UInt(Zn);
integer d = UInt(Zd);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
00	00	RESERVED
00	01	B
00	1x	H
01	xx	S
1x	xx	D

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<const> Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) result;

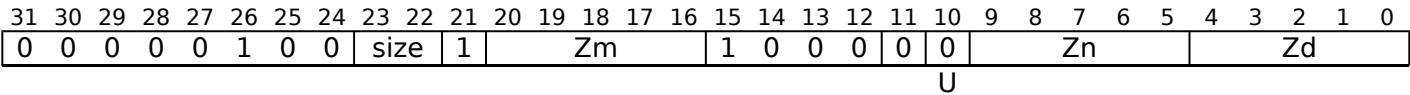
for e = 0 to elements-1
  bits(esize) element1 = Elem[operand1, e, esize];
  Elem[result, e, esize] = ASR(element1, shift);

Z[d] = result;
```

ASR (wide elements, unpredicated)

Arithmetic shift right by 64-bit wide elements (unpredicated)

Shift right, preserving the sign bit, all elements of the first source vector by corresponding overlapping 64-bit elements of the second source vector and place the first in the corresponding elements of the destination vector. The shift amount is a vector of unsigned 64-bit doubleword elements in which all bits are significant, and not used modulo the destination element size. This instruction is unpredicated.



ASR <Zd>.<T>, <Zn>.<T>, <Zm>.<D>

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	RESERVED

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

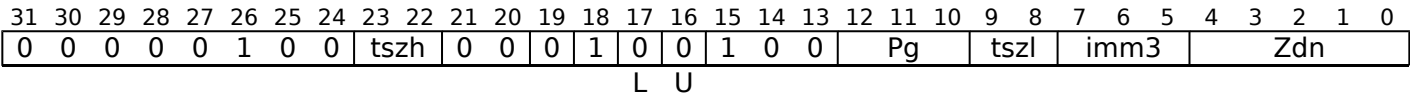
for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(64) element2 = Elem[operand2, (e * esize) DIV 64, 64];
    integer shift = Min(UInt(element2), esize);
    Elem[result, e, esize] = ASR(element1, shift);

Z[d] = result;
```

ASRD

Arithmetic shift right for divide by immediate (predicated)

Shift right by immediate, preserving the sign bit, each active element of the source vector, and destructively place the results in the corresponding elements of the source vector. The result rounds toward zero as in a signed division. The immediate shift amount is an unsigned value in the range 1 to number of bits per element. Inactive elements in the destination vector register remain unmodified.



ASRD <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, #<const>

```
if !HaveSVE() then UNDEFINED;
bits(4) tsize = tszh:tszl;
case tsize of
    when '0000' UNDEFINED;
    when '0001' esize = 8;
    when '001x' esize = 16;
    when '01xx' esize = 32;
    when '1xxx' esize = 64;
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
00	00	RESERVED
00	01	B
00	1x	H
01	xx	S
1x	xx	D
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <const> Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer element1 = SInt(Elem[operand1, e, esize]);
        if element1 < 0 then
            element1 = element1 + ((1 << shift) - 1);
        Elem[result, e, esize] = (element1 >> shift)<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

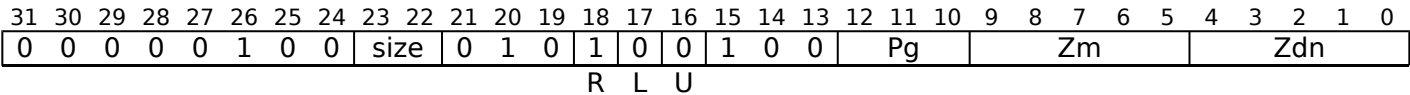
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

ASRR

Reversed arithmetic shift right by vector (predicated)

Reversed shift right, preserving the sign bit, active elements of the second source vector by corresponding elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. The shift amount operand is a vector of unsigned elements in which all bits are significant, and not used modulo the element size. Inactive elements in the destination vector register remain unmodified.



ASRR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element1 = Elem[operand1, e, esize];
        bits(esize) element2 = Elem[operand2, e, esize];
        integer shift = Min(UInt(element1), esize);
        Elem[result, e, esize] = ASR(element2, shift);
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# BFCVT

Floating-point down convert to BFloat16 format (predicated)

Convert to BFloat16 from single-precision in each active floating-point element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

Since the result type is smaller than the input type, the results are zero-extended to fill each destination element.

Unlike the BFloat16 matrix multiplication and dot product instructions, this instruction honors all of the FPCR bits that apply to single-precision arithmetic. It can also generate a floating-point exception that causes cumulative exception bits in the FPSR to be set, or a synchronous exception to be taken, depending on the enable bits in the FPCR.

ID\_AA64ZFR0\_EL1.BF16 indicates whether this instruction is implemented.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	1	0	0	0	1	0	1	0	1	0	1	Pg			Zn			Zd						

BFCVT <Zd>.H, <Pg>/M, <Zn>.S

```
if !HaveSVE() || !HaveBF16Ext() then UNDEFINED;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV 32;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, 32) then Z[n] else Zeros();
bits(VL) result = Z[d];

for e = 0 to elements-1
    if ElemP[mask, e, 32] == '1' then
        bits(32) element = Elem[operand, e, 32];
        Elem[result, 2*e, 16] = FPCConvertBF(element, FPCR[]);
        Elem[result, 2*e+1, 16] = Zeros();

Z[d] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



BFCVTNT

Floating-point down convert and narrow to BFloat16 (top, predicated)

Convert active 32-bit single-precision elements from the source vector to BFloat16 format, and place the results in the odd-numbered 16-bit elements of the destination vector, leaving the even-numbered elements unchanged. Inactive elements in the destination vector register remain unmodified.

Unlike the BFloat16 matrix multiplication and dot product instructions, this instruction honors all of the FPCR bits that apply to single-precision arithmetic. It can also generate a floating-point exception that causes cumulative exception bits in the FPSR to be set, or a synchronous exception to be taken, depending on the enable bits in the FPCR.

ID\_AA64ZFR0\_EL1.BF16 indicates whether this instruction is implemented.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	1	0	0	0	1	0	1	0	1	0	1	Pg			Zn			Zd						

BFCVTNT <Zd>.H, <Pg>/M, <Zn>.S

```
if !HaveSVE() || !HaveBF16Ext() then UNDEFINED;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV 32;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, 32) then Z[n] else Zeros();
bits(VL) result = Z[d];

for e = 0 to elements-1
    if ElemP[mask, e, 32] == '1' then
        bits(32) element = Elem[operand, e, 32];
        Elem[result, 2*e+1, 16] = FPConvertBF(element, FPCR[]);

Z[d] = result;
```

# BFDOT (vectors)

BFloat16 floating-point dot product

The BFloat16 floating-point (BF16) dot product instruction computes the dot product of a pair of BF16 values held in each 32-bit element of the first source vector multiplied by a pair of BF16 values in the corresponding 32-bit element of the second source vector, and then destructively adds the single-precision dot product to the corresponding single-precision element of the destination vector.

This instruction is unpredicated.

All floating-point calculations performed by this instruction are performed with the following behaviors, irrespective of the value in FPCR:

- \* Uses the non-IEEE 754 Round-to-Odd mode, which forces bit 0 of an inexact result to 1, and rounds an overflow to an appropriately signed Infinity.

- \* The cumulative FPSR exception bits (IDC, IXC, UFC, OFC, DZC and IOC) are not modified.

- \* Trapped floating-point exceptions are disabled, as if the FPCR trap enable bits (IDE, IXE, UFE, OFE, DZE and IOE) are all zero.

- \* Denormalized inputs and results are flushed to zero, as if FPCR.FZ == 1.

- \* Only the Default NaN is generated, as if FPCR.DN == 1.

ID\_AA64ZFR0\_EL1.BF16 indicates whether this instruction is implemented.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	0	1	1	Zm				1	0	0	0	0	0	Zn				Zda						

BFDOT <Zda>.S, <Zn>.H, <Zm>.H

```
if !HaveSVE() || !HaveBF16Ext() then UNDEFINED;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV 32;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    bits(16) elt1_a = Elem[operand1, 2 * e + 0, 16];
    bits(16) elt1_b = Elem[operand1, 2 * e + 1, 16];
    bits(16) elt2_a = Elem[operand2, 2 * e + 0, 16];
    bits(16) elt2_b = Elem[operand2, 2 * e + 1, 16];
    bits(32) sum = Elem[operand3, e, 32];

    sum = BFDotAdd(sum, elt1_a, elt1_b, elt2_a, elt2_b, FPCR[]);
    Elem[result, e, 32] = sum;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# BFDOT (indexed)

BFloat16 floating-point indexed dot product

The BFloat16 floating-point (BF16) indexed dot product instruction computes the dot product of a pair of BF16 values held in each 32-bit element of the first source vector multiplied by a pair of BF16 values in an indexed 32-bit element of the second source vector, and then destructively adds the single-precision dot product to the corresponding single-precision element of the destination vector.

The BF16 pairs within the second source vector are specified using an immediate index which selects the same BF16 pair position within each 128-bit vector segment. The index range is from 0 to 3. This instruction is unpredicated.

All floating-point calculations performed by this instruction are performed with the following behaviors, irrespective of the value in FPCR:

- \* Uses the non-IEEE 754 Round-to-Odd mode, which forces bit 0 of an inexact result to 1, and rounds an overflow to an appropriately signed Infinity.
- \* The cumulative FPSR exception bits (IDC, IXC, UFC, OFC, DZC and IOC) are not modified.
- \* Trapped floating-point exceptions are disabled, as if the FPCR trap enable bits (IDE, IXE, UFE, OFE, DZE and IOE) are all zero.
- \* Denormalized inputs and results are flushed to zero, as if FPCR.FZ == 1.
- \* Only the Default NaN is generated, as if FPCR.DN == 1.

ID\_AA64ZFR0\_EL1.BF16 indicates whether this instruction is implemented.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	0	1	1	i2		Zm		0	1	0	0	0	0		Zn					Zda				

BFDOT <Zda>.S, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE() || !HaveBF16Ext() then UNDEFINED;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer index = UInt(i2);
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.
- <imm> Is the immediate index, in the range 0 to 3, encoded in the "i2" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV 32;
integer eltspersegment = 128 DIV 32;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltspersegment);
    integer s = segmentbase + index;
    bits(16) elt1_a = Elem[operand1, 2 * e + 0, 16];
    bits(16) elt1_b = Elem[operand1, 2 * e + 1, 16];
    bits(16) elt2_a = Elem[operand2, 2 * s + 0, 16];
    bits(16) elt2_b = Elem[operand2, 2 * s + 1, 16];
    bits(32) sum = Elem[operand3, e, 32];

    sum = BFDotAdd(sum, elt1_a, elt1_b, elt2_a, elt2_b, FPCR[]);
    Elem[result, e, 32] = sum;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

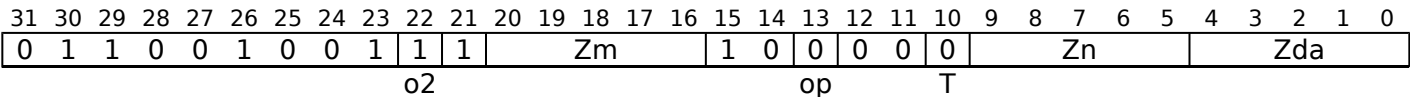
# BFMLALB (vectors)

BFloat16 floating-point multiply-add long to single-precision (bottom)

This BFloat16 floating-point multiply-add long instruction widens the even-numbered 16-bit BFloat16 elements in the first source vector and the corresponding elements in the second source vector to single-precision format and then destructively multiplies and adds these values without intermediate rounding to the overlapping 32-bit single-precision elements of the addend and destination vector. This instruction is unpredicated.

Unlike the BFloat16 matrix multiplication and dot product instructions, this instruction performs a fused multiply-add that honors all of the FPCR bits that apply to single-precision arithmetic. It can also generate a floating-point exception that causes cumulative exception bits in the FPSR to be set, or a synchronous exception to be taken, depending on the enable bits in the FPCR.

ID\_AA64ZFR0\_EL1.BF16 indicates whether this instruction is implemented.



BFMLALB <Zda>.S, <Zn>.H, <Zm>.H

```
if !HaveSVE() || !HaveBF16Ext() then UNDEFINED;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV 32;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    bits(32) element1 = Elem[operand1, 2 * e + 0, 16] : Zeros(16);
    bits(32) element2 = Elem[operand2, 2 * e + 0, 16] : Zeros(16);
    bits(32) element3 = Elem[operand3, e, 32];
    Elem[result, e, 32] = BFMulAdd(element3, element1, element2, FPCR[]);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

# BFMLALB (indexed)

BFloat16 floating-point multiply-add long to single-precision (bottom, indexed)

This BFloat16 floating-point multiply-add long instruction widens the even-numbered 16-bit BFloat16 elements in the first source vector and the indexed element from the corresponding 128-bit segment in the second source vector to single-precision format and then destructively multiplies and adds these values without intermediate rounding to the overlapping 32-bit single-precision elements of the addend and destination vector. This instruction is unpredicated. Unlike the BFloat16 matrix multiplication and dot product instructions, this instruction performs a fused multiply-add that honors all of the FPCR bits that apply to single-precision arithmetic. It can also generate a floating-point exception that causes cumulative exception bits in the FPSR to be set, or a synchronous exception to be taken, depending on the enable bits in the FPCR.

ID\_AA64ZFR0\_EL1.BF16 indicates whether this instruction is implemented.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	1	1	1	i3h		Zm		0	1	0	0	i3l	0				Zn					Zda		
o2										op										T											

BFMLALB <Zda>.S, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE() || !HaveBF16Ext() then UNDEFINED;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer index = UInt(i3h:i3l);
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.
- <imm> Is the immediate index, in the range 0 to 7, encoded in the "i3h:i3l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV 32;
integer eltsperssegment = 128 DIV 32;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltsperssegment);
    integer s = 2 * segmentbase + index;
    bits(32) element1 = Elem[operand1, 2 * e + 0, 16] : Zeros(16);
    bits(32) element2 = Elem[operand2, s, 16] : Zeros(16);
    bits(32) element3 = Elem[operand3, e, 32];
    Elem[result, e, 32] = BFMulAdd(element3, element1, element2, FPCR[]);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# BFMLALT (vectors)

BFloat16 floating-point multiply-add long to single-precision (top)

This BFloat16 floating-point multiply-add long instruction widens the odd-numbered 16-bit BFloat16 elements in the first source vector and the corresponding elements in the second source vector to single-precision format and then destructively multiplies and adds these values without intermediate rounding to the overlapping 32-bit single-precision elements of the addend and destination vector. This instruction is unpredicated.

Unlike the BFloat16 matrix multiplication and dot product instructions, this instruction performs a fused multiply-add that honors all of the FPCR bits that apply to single-precision arithmetic. It can also generate a floating-point exception that causes cumulative exception bits in the FPSR to be set, or a synchronous exception to be taken, depending on the enable bits in the FPCR.

ID\_AA64ZFR0\_EL1.BF16 indicates whether this instruction is implemented.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	1	1	1					Zm		1	0	0	0	0	1					Zn				Zda
o2										op										T											

BFMLALT <Zda>.S, <Zn>.H, <Zm>.H

```
if !HaveSVE() || !HaveBF16Ext() then UNDEFINED;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV 32;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    bits(32) element1 = Elem[operand1, 2 * e + 1, 16] : Zeros(16);
    bits(32) element2 = Elem[operand2, 2 * e + 1, 16] : Zeros(16);
    bits(32) element3 = Elem[operand3, e, 32];
    Elem[result, e, 32] = BFMulAdd(element3, element1, element2, FPCR[]);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

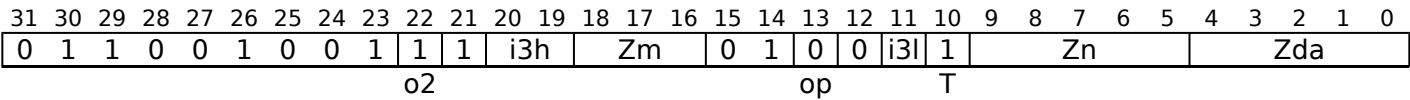
- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

# BFMLALT (indexed)

BFloat16 floating-point multiply-add long to single-precision (top, indexed)

This BFloat16 floating-point multiply-add long instruction widens the odd-numbered 16-bit BFloat16 elements in the first source vector and the indexed element from the corresponding 128-bit segment in the second source vector to single-precision format and then destructively multiplies and adds these values without intermediate rounding to the overlapping 32-bit single-precision elements of the addend and destination vector. This instruction is unpredicated. Unlike the BFloat16 matrix multiplication and dot product instructions, this instruction performs a fused multiply-add that honors all of the FPCR bits that apply to single-precision arithmetic. It can also generate a floating-point exception that causes cumulative exception bits in the FPSR to be set, or a synchronous exception to be taken, depending on the enable bits in the FPCR.

ID\_AA64ZFR0\_EL1.BF16 indicates whether this instruction is implemented.



BFMLALT <Zda>.S, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE() || !HaveBF16Ext() then UNDEFINED;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer index = UInt(i3h:i3l);
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.
- <imm> Is the immediate index, in the range 0 to 7, encoded in the "i3h:i3l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV 32;
integer eltsperssegment = 128 DIV 32;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltsperssegment);
    integer s = 2 * segmentbase + index;
    bits(32) element1 = Elem[operand1, 2 * e + 1, 16] : Zeros(16);
    bits(32) element2 = Elem[operand2, s, 16] : Zeros(16);
    bits(32) element3 = Elem[operand3, e, 32];
    Elem[result, e, 32] = BFMulAdd(element3, element1, element2, FPCR[]);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

BFMMLA

BFloat16 floating-point matrix multiply-accumulate

This BFloat16 floating-point (BF16) matrix multiply-accumulate instruction multiplies the 2×4 matrix of BF16 values held in each 128-bit segment of the first source vector by the 4×2 BF16 matrix in the corresponding segment of the second source vector. The resulting 2×2 single-precision (FP32) matrix product is then destructively added to the FP32 matrix accumulator held in the corresponding segment of the addend and destination vector. This is equivalent to performing a 4-way dot product per destination element.

This instruction is unpredicated and vector length agnostic.

All floating-point calculations performed by this instruction are performed with the following behaviors, irrespective of the value in FPCR:

- \* Uses the non-IEEE 754 Round-to-Odd mode, which forces bit 0 of an inexact result to 1, and rounds an overflow to an appropriately signed Infinity.
- \* The cumulative FPSR exception bits (IDC, IXC, UFC, OFC, DZC and IOC) are not modified.
- \* Trapped floating-point exceptions are disabled, as if the FPCR trap enable bits (IDE, IXE, UFE, OFE, DZE and IOE) are all zero.
- \* Denormalized inputs and results are flushed to zero, as if FPCR.FZ == 1.
- \* Only the Default NaN is generated, as if FPCR.DN == 1.

ID\_AA64ZFR0\_EL1.BF16 indicates whether this instruction is implemented.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	0	1	1	Zm				1	1	1	0	0	1	Zn				Zda						

BFMMLA <Zda>.S, <Zn>.H, <Zm>.H

```
if !HaveSVE() || !HaveBF16Ext() then UNDEFINED;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer segments = VL DIV 128;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;
bits(128) op1, op2;
bits(128) res, addend;

for s = 0 to segments-1
    op1 = Elem[operand1, s, 128];
    op2 = Elem[operand2, s, 128];
    addend = Elem[operand3, s, 128];
    res = BFMATMulAdd(addend, op1, op2);
    Elem[result, s, 128] = res;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# BIC (immediate)

Bitwise clear bits using immediate (unpredicated)

Bitwise clear bits using immediate with each 64-bit element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate is a 64-bit value consisting of a single run of ones or zeros repeating every 2, 4, 8, 16, 32 or 64 bits. This instruction is unpredicated.

This is a pseudo-instruction of [AND \(immediate\)](#). This means:

- The encodings in this description are named to match the encodings of [AND \(immediate\)](#).
- The assembler syntax is used only for assembly, and is not used on disassembly.
- The description of [AND \(immediate\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	1	0	0	0	0	0	imm13														Zdn			

BIC <Zdn>.<T>, <Zdn>.<T>, #<const>

is equivalent to

AND <Zdn>.<T>, <Zdn>.<T>, #(-<const> - 1)

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "imm13<12>:imm13<5:0>":

imm13<12>	imm13<5:0>	<T>
0	0xxxxx	S
0	10xxxx	H
0	110xxx	B
0	1110xx	B
0	11110x	B
0	111110	RESERVED
0	111111	RESERVED
1	xxxxxx	D

<const> Is a 64, 32, 16 or 8-bit bitmask consisting of replicated 2, 4, 8, 16, 32 or 64 bit fields, each field containing a rotated run of non-zero bits, encoded in the "imm13" field.

## Operation

The description of [AND \(immediate\)](#) gives the operational pseudocode for this instruction.

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# BIC, BICS (predicates)

Bitwise clear predicates

Bitwise AND inverted active elements of the second source predicate with corresponding elements of the first source predicate and place the results in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Optionally sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

It has encodings from 2 classes: [Not setting the condition flags](#) and [Setting the condition flags](#)

## Not setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	0	0	0	Pm				0	1	Pg				0	Pn				1	Pd			
S																															

BIC <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = FALSE;
```

## Setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	1	0	0	Pm				0	1	Pg				0	Pn				1	Pd			
S																															

BICS <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = TRUE;
```

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.
- <Pm> Is the name of the second source scalable predicate register, encoded in the "Pm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(PL) operand1 = P[n];
bits(PL) operand2 = P[m];
bits(PL) result;

for e = 0 to elements-1
    bit element1 = ElemP[operand1, e, esize];
    bit element2 = ElemP[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        ElemP[result, e, esize] = element1 AND (NOT element2);
    else
        ElemP[result, e, esize] = '0';

if setflags then
    PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# BIC (vectors, predicated)

Bitwise clear vectors (predicated)

Bitwise AND inverted active elements of the second source vector with corresponding elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	0	1	1	0	0	0		Pg												

BIC <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = element1 AND (NOT element2);
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



# BIC (vectors, unpredicated)

Bitwise clear vectors (unpredicated)

Bitwise AND inverted all elements of the second source vector with corresponding elements of the first source vector and place the results in the corresponding elements of the destination vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	1	1	Zm					0	0	1	1	0	0	Zn					Zd				

BIC <Zd>.D, <Zn>.D, <Zm>.D

```
if !HaveSVE() then UNDEFINED;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];

Z[d] = operand1 AND (NOT operand2);
```

# BRKA, BRKAS

Break after first true condition

Sets destination predicate elements up to and including the first active and true source element to true, then sets subsequent elements to false. Inactive elements in the destination predicate register remain unmodified or are set to zero, depending on whether merging or zeroing predication is selected. Optionally sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

It has encodings from 2 classes: [Not setting the condition flags](#) and [Setting the condition flags](#)

## Not setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	0	0	1	0	0	0	0	0	1	Pg			0	Pn			M	Pd					
								B		S																					

BRKA <Pd>.B, <Pg>/<ZM>, <Pn>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer d = UInt(Pd);
boolean merging = (M == '1');
boolean setflags = FALSE;
```

## Setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	1	0	1	0	0	0	0	0	1	Pg			0	Pn			0	Pd					
B S																		M													

BRKAS <Pd>.B, <Pg>/Z, <Pn>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer d = UInt(Pd);
boolean merging = FALSE;
boolean setflags = TRUE;
```

## Assembler Symbols

<Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.

<Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.

<ZM> Is the predication qualifier, encoded in "M":

M	<ZM>
0	Z
1	M

<Pn> Is the name of the source scalable predicate register, encoded in the "Pn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(PL) operand = P[n];
bits(PL) operand2 = P[d];
boolean break = FALSE;
bits(PL) result;

for e = 0 to elements-1
    boolean element = ElemP[operand, e, esize] == '1';
    if ElemP[mask, e, esize] == '1' then
        ElemP[result, e, esize] = if !break then '1' else '0';
        break = break || element;
    elsif merging then
        ElemP[result, e, esize] = ElemP[operand2, e, esize];
    else
        ElemP[result, e, esize] = '0';

if setflags then
    PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# BRKB, BRKBS

Break before first true condition

Sets destination predicate elements up to but not including the first active and true source element to true, then sets subsequent elements to false. Inactive elements in the destination predicate register remain unmodified or are set to zero, depending on whether merging or zeroing predication is selected. Optionally sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

It has encodings from 2 classes: [Not setting the condition flags](#) and [Setting the condition flags](#)

## Not setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	1	0	0	1	0	0	0	0	0	1	Pg			0	Pn			M	Pd					
								B		S																					

BRKB <Pd>.B, <Pg>/<ZM>, <Pn>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer d = UInt(Pd);
boolean merging = (M == '1');
boolean setflags = FALSE;
```

## Setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	1	1	0	1	0	0	0	0	0	1	Pg			0	Pn			0	Pd					
B										S										M											

BRKBS <Pd>.B, <Pg>/Z, <Pn>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer d = UInt(Pd);
boolean merging = FALSE;
boolean setflags = TRUE;
```

## Assembler Symbols

<Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.

<Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.

<ZM> Is the predication qualifier, encoded in "M":

M	<ZM>
0	Z
1	M

<Pn> Is the name of the source scalable predicate register, encoded in the "Pn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(PL) operand = P[n];
bits(PL) operand2 = P[d];
boolean break = FALSE;
bits(PL) result;

for e = 0 to elements-1
    boolean element = ElemP[operand, e, esize] == '1';
    if ElemP[mask, e, esize] == '1' then
        break = break || element;
        ElemP[result, e, esize] = if !break then '1' else '0';
    elseif merging then
        ElemP[result, e, esize] = ElemP[operand2, e, esize];
    else
        ElemP[result, e, esize] = '0';

if setflags then
    PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

BRKN, BRKNS

Propagate break to next partition

If the last active element of the first source predicate is false then set the destination predicate to all-false. Otherwise leaves the destination and second source predicate unchanged. Optionally sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

It has encodings from 2 classes: [Not setting the condition flags](#) and [Setting the condition flags](#)

Not setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	0	0	1	1	0	0	0	0	1	Pg			0	Pn			0	Pdm					
S																															

BRKN <Pdm>.B, <Pg>/Z, <Pn>.B, <Pdm>.B

```
if !HaveSVE() then UNDEFINED;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer dm = UInt(Pdm);
boolean setflags = FALSE;
```

Setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	1	0	1	1	0	0	0	0	1	Pg			0	Pn			0	Pdm					
S																															

BRKNS <Pdm>.B, <Pg>/Z, <Pn>.B, <Pdm>.B

```
if !HaveSVE() then UNDEFINED;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer dm = UInt(Pdm);
boolean setflags = TRUE;
```

Assembler Symbols

- <Pdm> Is the name of the second source and destination scalable predicate register, encoded in the "Pdm" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.



## Operation

```
CheckSVEEnabled();
bits(PL) mask = P[g];
bits(PL) operand1 = P[n];
bits(PL) operand2 = P[dm];
bits(PL) result;

if LastActive(mask, operand1, 8) == '1' then
    result = operand2;
else
    result = Zeros();

if setflags then
    PSTATE.<N,Z,C,V> = PredTest(Ones(PL), result, 8);
P[dm] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# BRKPA, BRKPAS

Break after first true condition, propagating from previous partition

If the last active element of the first source predicate is false then set the destination predicate to all-false. Otherwise sets destination predicate elements up to and including the first active and true source element to true, then sets subsequent elements to false. Inactive elements in the destination predicate register are set to zero. Optionally sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

It has encodings from 2 classes: [Not setting the condition flags](#) and [Setting the condition flags](#)

## Not setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	0	0	0	Pm				1	1	Pg				0	Pn				0	Pd			
S																B															

BRKPA <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = FALSE;
```

## Setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	1	0	0	Pm				1	1	Pg				0	Pn				0	Pd			
S																B															

BRKPAS <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = TRUE;
```

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.
- <Pm> Is the name of the second source scalable predicate register, encoded in the "Pm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(PL) operand1 = P[n];
bits(PL) operand2 = P[m];
bits(PL) result;
boolean last = (LastActive(mask, operand1, 8) == '1');

for e = 0 to elements-1
    if ElemP[mask, e, 8] == '1' then
        ElemP[result, e, 8] = if last then '1' else '0';
        last = last && (ElemP[operand2, e, 8] == '0');
    else
        ElemP[result, e, 8] = '0';

if setflags then
    PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# BRKPB, BRKPBS

Break before first true condition, propagating from previous partition

If the last active element of the first source predicate is false then set the destination predicate to all-false. Otherwise sets destination predicate elements up to but not including the first active and true source element to true, then sets subsequent elements to false. Inactive elements in the destination predicate register are set to zero. Optionally sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

It has encodings from 2 classes: [Not setting the condition flags](#) and [Setting the condition flags](#)

## Not setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	0	0	0	Pm				1	1	Pg				0	Pn				1	Pd			
S																B															

BRKPB <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = FALSE;
```

## Setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	1	0	0	Pm				1	1	Pg				0	Pn				1	Pd			
S																B															

BRKPBS <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = TRUE;
```

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.
- <Pm> Is the name of the second source scalable predicate register, encoded in the "Pm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(PL) operand1 = P[n];
bits(PL) operand2 = P[m];
bits(PL) result;
boolean last = (LastActive(mask, operand1, 8) == '1');

for e = 0 to elements-1
    if ElemP[mask, e, 8] == '1' then
        last = last && (ElemP[operand2, e, 8] == '0');
        ElemP[result, e, 8] = if last then '1' else '0';
    else
        ElemP[result, e, 8] = '0';

if setflags then
    PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

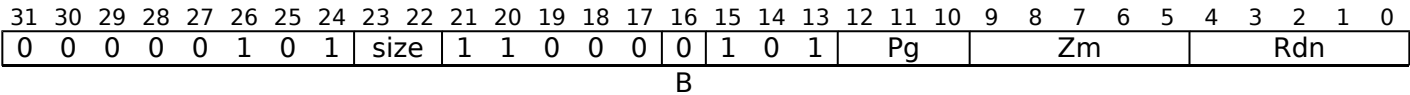
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

CLASTA (scalar)

Conditionally extract element after last to general-purpose register

From the source vector register extract the element after the last active element, or if the last active element is the final element extract element zero, and then zero-extend that element to destructively place in the destination and first source general-purpose register. If there are no active elements then destructively zero-extend the least significant element-size bits of the destination and first source general-purpose register.



CLASTA <R><dn>, <Pg>, <R><dn>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Rdn);
integer m = UInt(Zm);
integer csize = if esize < 64 then 32 else 64;
boolean isBefore = FALSE;
```

Assembler Symbols

<R> Is a width specifier, encoded in “size”:

size	<R>
01	W
x0	W
11	X

<dn> Is the number [0-30] of the source and destination general-purpose register or the name ZR (31), encoded in the "Rdn" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the source scalable vector register, encoded in the "Zm" field.

<T> Is the size specifier, encoded in “size”:

size	<T>
00	B
01	H
10	S
11	D

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(esize) operand1 = X[dn];
bits(VL) operand2 = Z[m];
bits(csize) result;
integer last = LastActiveElement(mask, esize);

if last < 0 then
    result = ZeroExtend(operand1);
else
    if !isBefore then
        last = last + 1;
        if last >= elements then last = 0;
    result = ZeroExtend(Elem[operand2, last, esize]);

X[dn] = result;
```

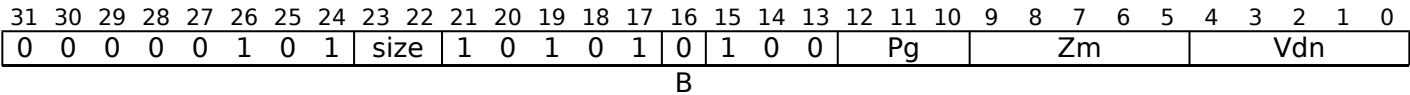
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

CLASTA (SIMD&FP scalar)

Conditionally extract element after last to SIMD&FP scalar register

From the source vector register extract the element after the last active element, or if the last active element is the final element extract element zero, and then zero-extend that element to destructively place in the destination and first source SIMD & floating-point scalar register. If there are no active elements then destructively zero-extend the least significant element-size bits of the destination and first source SIMD & floating-point scalar register.



CLASTA <V><dn>, <Pg>, <V><dn>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Vdn);
integer m = UInt(Zm);
boolean isBefore = FALSE;
```

Assembler Symbols

<V> Is a width specifier, encoded in "size":

size	<V>
00	B
01	H
10	S
11	D

<dn> Is the number [0-31] of the source and destination SIMD&FP register, encoded in the "Vdn" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the source scalable vector register, encoded in the "Zm" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(esize) operand1 = V[dn];
bits(VL) operand2 = Z[m];
bits(esize) result;
integer last = LastActiveElement(mask, esize);

if last < 0 then
    result = ZeroExtend(operand1);
else
    if !isBefore then
        last = last + 1;
        if last >= elements then last = 0;
    result = Elem[operand2, last, esize];

V[dn] = result;
```

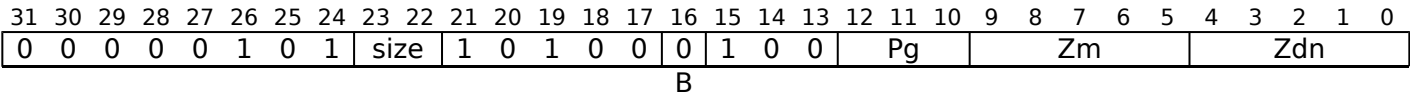
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

CLASTA (vectors)

Conditionally extract element after last to vector register

From the second source vector register extract the element after the last active element, or if the last active element is the final element extract element zero, and then replicate that element to destructively fill the destination and first source vector.  
If there are no active elements then leave the destination and source vector unmodified.



```
CLASTA <Zdn>.<T>, <Pg>, <Zdn>.<T>, <Zm>.<T>
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean isBefore = FALSE;
```

Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;
integer last = LastActiveElement(mask, esize);

if last < 0 then
    result = operand1;
else
    if !isBefore then
        last = last + 1;
        if last >= elements then last = 0;
    for e = 0 to elements-1
        Elem[result, e, esize] = Elem[operand2, last, esize];
Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

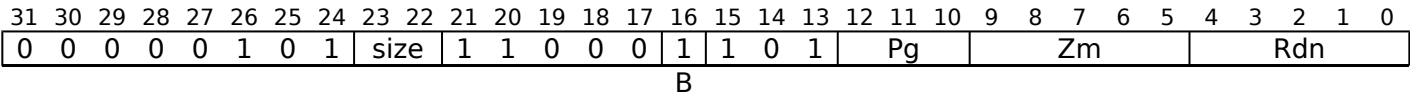
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

CLASTB (scalar)

Conditionally extract last element to general-purpose register

From the source vector register extract the last active element, and then zero-extend that element to destructively place in the destination and first source general-purpose register. If there are no active elements then destructively zero-extend the least significant element-size bits of the destination and first source general-purpose register.



CLASTB <R><dn>, <Pg>, <R><dn>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Rdn);
integer m = UInt(Zm);
integer csize = if esize < 64 then 32 else 64;
boolean isBefore = TRUE;
```

Assembler Symbols

<R> Is a width specifier, encoded in "size":

size	<R>
01	W
x0	W
11	X

<dn> Is the number [0-30] of the source and destination general-purpose register or the name ZR (31), encoded in the "Rdn" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the source scalable vector register, encoded in the "Zm" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(esize) operand1 = X[dn];
bits(VL) operand2 = Z[m];
bits(csize) result;
integer last = LastActiveElement(mask, esize);

if last < 0 then
    result = ZeroExtend(operand1);
else
    if !isBefore then
        last = last + 1;
        if last >= elements then last = 0;
    result = ZeroExtend(Elem[operand2, last, esize]);

X[dn] = result;
```

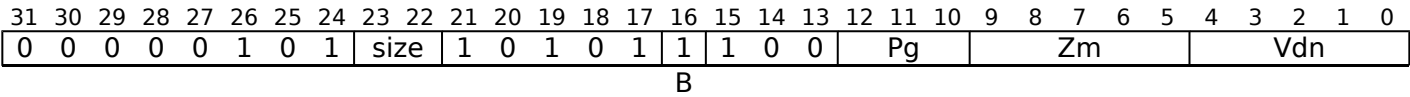
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

CLASTB (SIMD&FP scalar)

Conditionally extract last element to SIMD&FP scalar register

From the source vector register extract the last active element, and then zero-extend that element to destructively place in the destination and first source SIMD & floating-point scalar register. If there are no active elements then destructively zero-extend the least significant element-size bits of the destination and first source SIMD & floating-point scalar register.



CLASTB <V><dn>, <Pg>, <V><dn>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Vdn);
integer m = UInt(Zm);
boolean isBefore = TRUE;
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D

<dn> Is the number [0-31] of the source and destination SIMD&FP register, encoded in the "Vdn" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the source scalable vector register, encoded in the "Zm" field.

<T> Is the size specifier, encoded in “size”:

size	<T>
00	B
01	H
10	S
11	D

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(esize) operand1 = V[dn];
bits(VL) operand2 = Z[m];
bits(esize) result;
integer last = LastActiveElement(mask, esize);

if last < 0 then
    result = ZeroExtend(operand1);
else
    if !isBefore then
        last = last + 1;
        if last >= elements then last = 0;
    result = Elem[operand2, last, esize];

V[dn] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

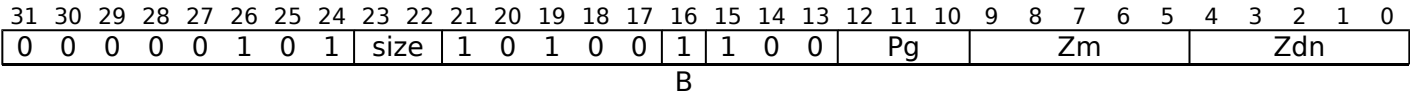
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# CLASTB (vectors)

Conditionally extract last element to vector register

From the second source vector register extract the last active element, and then replicate that element to destructively fill the destination and first source vector.

If there are no active elements then leave the destination and source vector unmodified.



CLASTB <Zdn>.<T>, <Pg>, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean isBefore = TRUE;
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;
integer last = LastActiveElement(mask, esize);

if last < 0 then
    result = operand1;
else
    if !isBefore then
        last = last + 1;
        if last >= elements then last = 0;
    for e = 0 to elements-1
        Elem[result, e, esize] = Elem[operand2, last, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:



- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

CLS

Count leading sign bits (predicated)

Count leading sign bits in each active element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	0	0	0	1	0	1	Pg													

CLS <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) result = Z[d];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element = Elem[operand, e, esize];
        Elem[result, e, esize] = CountLeadingSignBits(element)<esize-1:0>;

Z[d] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

CLZ

Count leading zero bits (predicated)

Count leading zero bits in each active element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	0	0	1	1	0	1	Pg													

CLZ <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) result = Z[d];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element = Elem[operand, e, esize];
        Elem[result, e, esize] = CountLeadingZeroBits(element)<esize-1:0>;

Z[d] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

# CMP<cc> (immediate)

Compare vector to immediate

Compare active integer elements in the source vector with an immediate, and place the boolean results of the specified comparison in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

The <cc> symbol specifies one of the standard ARM condition codes: EQ, GE, GT, HI, HS, LE, LO, LS, LT or NE.

It has encodings from 10 classes: [Equal](#) , [Greater than](#) , [Greater than or equal](#) , [Higher](#) , [Higher or same](#) , [Less than](#) , [Less than or equal](#) , [Lower](#) , [Lower or same](#) and [Not equal](#)

## Equal

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	0	imm5			1	0	0	Pg		Zn				0	Pd								
ne																															

CMPEQ <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_EQ;
integer imm = SInt(imm5);
boolean unsigned = FALSE;
```

## Greater than

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	0	imm5			0	0	0	Pg			Zn			1	Pd								
																lt										ne					

CMPGT <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_GT;
integer imm = SInt(imm5);
boolean unsigned = FALSE;
```

## Greater than or equal

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	0	imm5			0	0	0	Pg			Zn			0	Pd								
																lt										ne					

**CMPGE** <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_GE;
integer imm = SInt(imm5);
boolean unsigned = FALSE;
```

## Higher

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size	1	imm7							0	Pg				Zn				1	Pd				
																		lt				ne									

**CMPHI** <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_GT;
integer imm = UInt(imm7);
boolean unsigned = TRUE;
```

## Higher or same

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size	1	imm7							0	Pg				Zn				0	Pd				
																		lt				ne									

**CMPHS** <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_GE;
integer imm = UInt(imm7);
boolean unsigned = TRUE;
```

## Less than

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	0	1	0	0	1	0	1	size	0	imm5							0	0	1	Pg				Zn				0	Pd			
																		lt				ne										

**CMPLT** <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_LT;
integer imm = SInt(imm5);
boolean unsigned = FALSE;
```

## Less than or equal

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	0	imm5					0	0	1	Pg				Zn				1	Pd				
																	lt				ne										

**CMPLE** <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_LE;
integer imm = SInt(imm5);
boolean unsigned = FALSE;
```

## Lower

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size	1	imm7					1	Pg				Zn				0	Pd						
																	lt				ne										

**CMPLO** <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_LT;
integer imm = UInt(imm7);
boolean unsigned = TRUE;
```

## Lower or same

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size	1	imm7					1	Pg				Zn				1	Pd						
																	lt				ne										

**CMPLS** <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_LE;
integer imm = UInt(imm7);
boolean unsigned = TRUE;
```

## Not equal

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	0	imm5					1	0	0	Pg				Zn				1	Pd				
ne																															

**CMPNE** <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Comp_NE;
integer imm = SInt(imm5);
boolean unsigned = FALSE;
```

### Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <T> Is the size specifier, encoded in "size":
 

size	<T>
00	B
01	H
10	S
11	D
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.
- <imm> For the equal, greater than, greater than or equal, less than, less than or equal and not equal variant: is the signed immediate operand, in the range -16 to 15, encoded in the "imm5" field.  
For the higher, higher or same, lower and lower or same variant: is the unsigned immediate operand, in the range 0 to 127, encoded in the "imm7" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(PL) result;

for e = 0 to elements-1
  integer element1 = Int(Elem[operand1, e, esize], unsigned);
  if ElemP[mask, e, esize] == '1' then
    boolean cond;
    case op of
      when Comp_EQ cond = element1 == imm;
      when Comp_NE cond = element1 != imm;
      when Comp_GE cond = element1 >= imm;
      when Comp_LT cond = element1 < imm;
      when Comp_GT cond = element1 > imm;
      when Comp_LE cond = element1 <= imm;
    ElemP[result, e, esize] = if cond then '1' else '0';
  else
    ElemP[result, e, esize] = '0';

PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

# CMP<cc> (wide elements)

Compare vector to 64-bit wide elements

Compare active integer elements in the first source vector with overlapping 64-bit doubleword elements in the second source vector, and place the boolean results of the specified comparison in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

The <cc> symbol specifies one of the standard ARM condition codes: EQ, GE, GT, HI, HS, LE, LO, LS, LT or NE.

It has encodings from 10 classes: [Equal](#) , [Greater than](#) , [Greater than or equal](#) , [Higher](#) , [Higher or same](#) , [Less than](#) , [Less than or equal](#) , [Lower](#) , [Lower or same](#) and [Not equal](#)

## Equal

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	0	1	0	0	1	0	0	size	0	Zm						0	0	1	Pg				Zn					0	Pd			
																ne																

CMPEQ <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<D>

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_EQ;
boolean unsigned = FALSE;
```

## Greater than

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size	0	Zm						0	1	0	Pg			Zn					1	Pd			
																U		lt		ne											

CMPGT <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<D>

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_GT;
boolean unsigned = FALSE;
```

## Greater than or equal

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	0	1	0	0	1	0	0	size	0	Zm						0	1	0	Pg				Zn					0	Pd			
																U		lt		ne												



**CMPGE** <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<D>

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_GE;
boolean unsigned = FALSE;
```

**Higher**

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	0	1	0	0	1	0	0	size	0	Zm						1	1	0	Pg			Zn						1	Pd				
																U		lt														ne	

**CMPHI** <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<D>

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_GT;
boolean unsigned = TRUE;
```

**Higher or same**

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	0	1	0	0	1	0	0	size	0	Zm						1	1	0	Pg			Zn					0	Pd					
																U		lt														ne	

**CMPHS** <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<D>

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_GE;
boolean unsigned = TRUE;
```

**Less than**

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	0	1	0	0	1	0	0	size	0	Zm				0	1	1	Pg			Zn				0	Pd								
																U		lt														ne	

CMPLT <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.D

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_LT;
boolean unsigned = FALSE;
```

Less than or equal

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	0	1	0	0	1	0	0	size	0	Zm				0	1	1	Pg				Zn				1	Pd						
																U		lt														ne

CMPLT <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.D

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_LE;
boolean unsigned = FALSE;
```

Lower

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	0	1	0	0	1	0	0	size	0	Zm				1	1	1	Pg				Zn				0	Pd						
																U		lt														ne

CMPLT <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.D

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_LT;
boolean unsigned = TRUE;
```

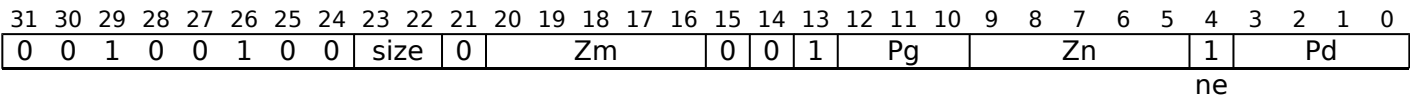
Lower or same

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	0	1	0	0	1	0	0	size	0	Zm				1	1	1	Pg				Zn				1	Pd						
																U		lt														ne

CMPLS <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.D

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_LE;
boolean unsigned = TRUE;
```

Not equal



CMPNE <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.D

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_NE;
boolean unsigned = FALSE;
```

Assembler Symbols

<Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	RESERVED

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(PL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    if ElemP[mask, e, esize] == '1' then
        boolean cond;
        integer element2 = Int(Elem[operand2, (e * esize) DIV 64, 64], unsigned);
        case op of
            when Cmp_EQ cond = element1 == element2;
            when Cmp_NE cond = element1 != element2;
            when Cmp_GE cond = element1 >= element2;
            when Cmp_LT cond = element1 < element2;
            when Cmp_GT cond = element1 > element2;
            when Cmp_LE cond = element1 <= element2;
        ElemP[result, e, esize] = if cond then '1' else '0';
    else
        ElemP[result, e, esize] = '0';

PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## CMP<cc> (vectors)

## Compare vectors

Compare active integer elements in the first source vector with corresponding elements in the second source vector, and place the boolean results of the specified comparison in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

The <cc> symbol specifies one of the standard ARM condition codes: EQ, GE, GT, HI, HS or NE.

This instruction is used by the pseudo-instructions [CMPLD \(vectors\)](#), [CMPLO \(vectors\)](#), [CMPLS \(vectors\)](#), and [CMPLT \(vectors\)](#).

It has encodings from 6 classes: [Equal](#) , [Greater than](#) , [Greater than or equal](#) , [Higher](#) , [Higher or same](#) and [Not equal](#)

## Equal

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size	0	Zm				1	0	1	Pg			Zn				0	Pd						
ne																															

CMPEO <Pd>.<T>.<Pq>/Z.<Zn>.<T>.<Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_EQ;
boolean unsigned = FALSE;
```

## Greater than

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size	0	Zm			1	0	0	Pg			Zn			1	Pd								
ne																															

**CMPGT** **<Pd>.<T>**, **<Pg>/Z**, **<Zn>.<T>**, **<Zm>.<T>**

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_GT;
boolean unsigned = FALSE;
```

## Greater than or equal

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size	0	Zm			1	0	0	Pg			Zn			0	Pd								

ne

**CMPGE** <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_GE;
boolean unsigned = FALSE;
```

## Higher

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size	0				Zm		0	0	0		Pg					Zn		1			Pd		
ne																															

**CMPHI** <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_GT;
boolean unsigned = TRUE;
```

## Higher or same

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size	0				Zm		0	0	0		Pg					Zn		0			Pd		
ne																															

**CMPHS** <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_GE;
boolean unsigned = TRUE;
```

## Not equal

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size	0				Zm		1	0	1		Pg					Zn		1			Pd		
ne																															

**CMPNE** <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_NE;
boolean unsigned = FALSE;
```

## Assembler Symbols

<Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(PL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    if ElemP[mask, e, esize] == '1' then
        boolean cond;
        integer element2 = Int(Elem[operand2, e, esize], unsigned);
        case op of
            when Cmp_EQ cond = element1 == element2;
            when Cmp_NE cond = element1 != element2;
            when Cmp_GE cond = element1 >= element2;
            when Cmp_LT cond = element1 < element2;
            when Cmp_GT cond = element1 > element2;
            when Cmp_LE cond = element1 <= element2;
        ElemP[result, e, esize] = if cond then '1' else '0';
    else
        ElemP[result, e, esize] = '0';

PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# CMPLE (vectors)

Compare signed less than or equal to vector, setting the condition flags

Compare active signed integer elements in the first source vector being less than or equal to corresponding signed elements in the second source vector, and place the boolean results of the comparison in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

This is a pseudo-instruction of [CMP<cc> \(vectors\)](#). This means:

- The encodings in this description are named to match the encodings of [CMP<cc> \(vectors\)](#).
- The assembler syntax is used only for assembly, and is not used on disassembly.
- The description of [CMP<cc> \(vectors\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size		0	Zm				1	0	0	Pg				Zn				0	Pd				
																												ne			

CMPLE <Pd>.<T>, <Pg>/Z, <Zm>.<T>, <Zn>.<T>

is equivalent to

CMPGE <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

## Operation

The description of [CMP<cc> \(vectors\)](#) gives the operational pseudocode for this instruction.



# CMPLO (vectors)

Compare unsigned lower than vector, setting the condition flags

Compare active unsigned integer elements in the first source vector being lower than corresponding unsigned elements in the second source vector, and place the boolean results of the comparison in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

This is a pseudo-instruction of [CMP<cc> \(vectors\)](#). This means:

- The encodings in this description are named to match the encodings of [CMP<cc> \(vectors\)](#).
- The assembler syntax is used only for assembly, and is not used on disassembly.
- The description of [CMP<cc> \(vectors\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size	0	Zm			0	0	0	Pg			Zn			1	Pd								
ne																															

CMPLO <Pd>.<T>, <Pg>/Z, <Zm>.<T>, <Zn>.<T>

is equivalent to

CMPHI <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

## Operation

The description of [CMP<cc> \(vectors\)](#) gives the operational pseudocode for this instruction.

## CMPLS (vectors)

Compare unsigned lower or same as vector, setting the condition flags

Compare active unsigned integer elements in the first source vector being lower than or same as corresponding unsigned elements in the second source vector, and place the boolean results of the comparison in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

This is a pseudo-instruction of [CMP<cc> \(vectors\)](#). This means:

- The encodings in this description are named to match the encodings of [CMP<cc> \(vectors\)](#).
- The assembler syntax is used only for assembly, and is not used on disassembly.
- The description of [CMP<cc> \(vectors\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size	0	Zm				0	0	0	Pg			Zn				0	Pd						
ne																															

**CMPLS** **<Pd>**.**<T>**, **<Pg>/Z**, **<Zm>**.**<T>**, **<Zn>**.**<T>**

**is equivalent to**

**CMPHS** **<Pd>.<T>**, **<Pg>/Z**, **<Zn>.<T>**, **<Zm>.<T>**

## Assembler Symbols

**<Pd>** Is the name of the destination scalable predicate register, encoded in the "Pd" field.

<b>&lt;Zm&gt;</b>	Is the name of the second source scalable vector register, encoded in the "Zm" field.
-------------------	---

**<Zn>** Is the name of the first source scalable vector register, encoded in the "Zn" field.

**<T>** Is the size specifier, encoded in “size”:

size	<T>
00	B
01	H
10	S
11	D

**<Pg>** Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

## Operation

The description of [CMP<cc> \(vectors\)](#) gives the operational pseudocode for this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# CMPLT (vectors)

Compare signed less than vector, setting the condition flags

Compare active signed integer elements in the first source vector being less than corresponding signed elements in the second source vector, and place the boolean results of the comparison in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

This is a pseudo-instruction of [CMP<cc> \(vectors\)](#). This means:

- The encodings in this description are named to match the encodings of [CMP<cc> \(vectors\)](#).
- The assembler syntax is used only for assembly, and is not used on disassembly.
- The description of [CMP<cc> \(vectors\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size		0	Zm				1	0	0	Pg				Zn				1	Pd				
ne																															

CMPLT <Pd>.<T>, <Pg>/Z, <Zm>.<T>, <Zn>.<T>

is equivalent to

CMPGT <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

## Operation

The description of [CMP<cc> \(vectors\)](#) gives the operational pseudocode for this instruction.

# CNOT

Logically invert boolean condition in vector (predicated)

Logically invert the boolean value in each active element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

Boolean TRUE is any non-zero value in a source, and one in a result element. Boolean FALSE is always zero.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	0	1	1	1	0	1	Pg	Zn			Zd									

CNOT <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) result = Z[d];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element = Elem[operand, e, esize];
        Elem[result, e, esize] = ZeroExtend(IsZeroBit(element), esize);

Z[d] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



# CNT

Count non-zero bits (predicated)

Count non-zero bits in each active element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	0	1	0	1	0	1	Pg													

CNT <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) result = Z[d];

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    bits(esize) element = Elem[operand, e, esize];
    Elem[result, e, esize] = BitCount(element)<esize-1:0>;

Z[d] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

# CNTB, CNTD, CNTH, CNTW

Set scalar to multiple of predicate constraint element count

Determines the number of active elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then places the result in the scalar destination.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 4 classes: [Byte](#) , [Doubleword](#) , [Halfword](#) and [Word](#)

## Byte

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	1	0	imm4				1	1	1	0	0	0	pattern					Rd				
size<1>size<0>																															

CNTB <Xd>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer d = UInt(Rd);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

## Doubleword

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	1	0	imm4				1	1	1	0	0	0	pattern					Rd					
size<1>size<0>																															

CNTD <Xd>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer d = UInt(Rd);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

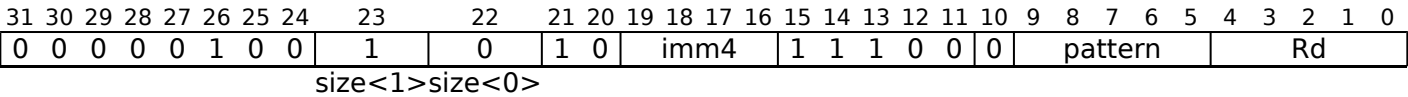
## Halfword

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1	0	imm4				1	1	1	0	0	0	pattern					Rd				
size<1>size<0>																															

CNTH <Xd>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer d = UInt(Rd);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

Word



```
CNTW <Xd>{, <pattern>{, MUL #<imm>}}
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer d = UInt(Rd);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

Assembler Symbols

- <Xd> Is the 64-bit name of the destination general-purpose register, encoded in the "Rd" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

Operation

```
CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
X[d] = (count * imm)<63:0>;
```



# CNTP

Set scalar to count of true predicate elements

Counts the number of active and true elements in the source predicate and places the scalar result in the destination general-purpose register. Inactive predicate elements are not counted.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size		1	0	0	0	0	0	1	0	Pg			0	Pn			Rd						

CNTP <Xd>, <Pg>, <Pn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Pn);
integer d = UInt(Rd);
```

## Assembler Symbols

- <Xd> Is the 64-bit name of the destination general-purpose register, encoded in the "Rd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the source scalable predicate register, encoded in the "Pn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(PL) operand = P[n];
bits(64) sum = Zeros();

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' && ElemP[operand, e, esize] == '1' then
        sum = sum + 1;
X[d] = sum;
```

COMPACT

Shuffle active elements of vector to the right and fill with zero

Read the active elements from the source vector and pack them into the lowest-numbered elements of the destination vector. Then set any remaining elements of the destination vector to zero.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1		size	1	0	0	0	0	1	1	0	0		Pg											

COMPACT <Zd>.<T>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '0x' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "size<0>":

size<0>	<T>
0	S
1	D
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) result = Zeros();
integer x = 0;

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element = Elem[operand1, e, esize];
        Elem[result, x, esize] = element;
        x = x + 1;

Z[d] = result;
```

# CPY (immediate, zeroing)

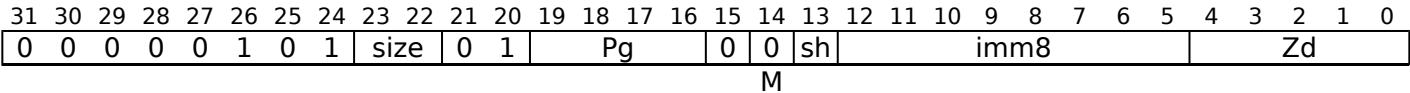
Copy signed integer immediate to vector elements (zeroing)

Copy a signed integer immediate to each active element in the destination vector. Inactive elements in the destination vector register are set to zero.

The immediate operand is a signed value in the range -128 to +127, and for element widths of 16 bits or higher it may also be a signed multiple of 256 in the range -32768 to +32512 (excluding 0).

The immediate is encoded in 8 bits with an optional left shift by 8. The preferred disassembly when the shift option is specified is "#<imm8>, LSL #8". However an assembler and disassembler may also allow use of the shifted 16-bit value unless the immediate is 0 and the shift amount is 8, which must be unambiguously described as "#0, LSL #8".

This instruction is used by the alias [MOV \(immediate, predicated, zeroing\)](#).



CPY <Zd>.<T>, <Pg>/Z, #<imm>{, <shift>}

```
if !HaveSVE() then UNDEFINED;
if size:sh == '001' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer d = UInt(Zd);
boolean merging = FALSE;
integer imm = SInt(imm8);
if sh == '1' then imm = imm << 8;
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.

<imm> Is a signed immediate in the range -128 to 127, encoded in the "imm8" field.

<shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #8

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) dest = Z[d];
bits(VL) result;

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = imm<esize-1:0>;
    elsif merging then
        Elem[result, e, esize] = Elem[dest, e, esize];
    else
        Elem[result, e, esize] = Zeros();
Z[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# CPY (immediate, merging)

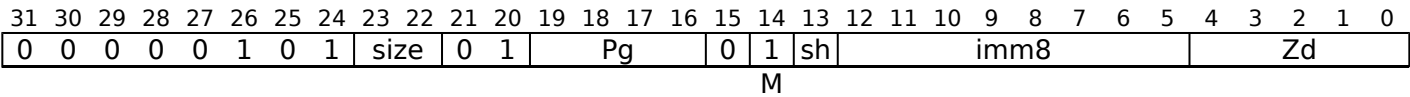
Copy signed integer immediate to vector elements (merging)

Copy a signed integer immediate to each active element in the destination vector. Inactive elements in the destination vector register remain unmodified.

The immediate operand is a signed value in the range -128 to +127, and for element widths of 16 bits or higher it may also be a signed multiple of 256 in the range -32768 to +32512 (excluding 0).

The immediate is encoded in 8 bits with an optional left shift by 8. The preferred disassembly when the shift option is specified is "#<simm8>, LSL #8". However an assembler and disassembler may also allow use of the shifted 16-bit value unless the immediate is 0 and the shift amount is 8, which must be unambiguously described as "#0, LSL #8".

This instruction is used by the aliases [FMOV \(zero, predicated\)](#), and [MOV \(immediate, predicated, merging\)](#).



CPY <Zd>.<T>, <Pg>/M, #<imm>[, <shift>]

```
if !HaveSVE() then UNDEFINED;
if size:sh == '001' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer d = UInt(Zd);
boolean merging = TRUE;
integer imm = SInt(imm8);
if sh == '1' then imm = imm << 8;
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.

<imm> Is a signed immediate in the range -128 to 127, encoded in the "imm8" field.

<shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #8

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) dest = Z[d];
bits(VL) result;

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = imm<esize-1:0>;
    elsif merging then
        Elem[result, e, esize] = Elem[dest, e, esize];
    else
        Elem[result, e, esize] = Zeros();

Z[d] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# CPY (scalar)

Copy general-purpose register to vector elements (predicated)

Copy the general-purpose scalar source register to each active element in the destination vector. Inactive elements in the destination vector register remain unmodified.

This instruction is used by the alias [MOV \(scalar, predicated\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	1	0	0	0	1	0	1	Pg			Rn				Zd						

CPY <Zd>.<T>, <Pg>/M, <R><n|SP>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Rn);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<R> Is a width specifier, encoded in "size":

size	<R>
01	W
x0	W
11	X

<n|SP> Is the number [0-30] of the general-purpose source register or the name SP (31), encoded in the "Rn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) result = Z[d];
if AnyActiveElement(mask, esize) then
    bits(64) operand1;
    if n == 31 then
        operand1 = SP[];
    else
        operand1 = X[n];

    for e = 0 to elements-1
        if ElemP[mask, e, esize] == '1' then
            Elem[result, e, esize] = operand1<esize-1:0>;

Z[d] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



## CPY (SIMD&FP scalar)

Copy SIMD&FP scalar register to vector elements (predicated)

Copy the SIMD & floating-point scalar source register to each active element in the destination vector. Inactive elements in the destination vector register remain unmodified.

This instruction is used by the alias [MOV \(SIMD&FP scalar, predicated\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size		1	0	0	0	0	0	1	0	0	Pg		Vn				Zd						

CPY <Zd>.<T>, <Pg>/M, <V><n>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Vn);
integer d = UInt(Zd);
```

### Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<V> Is a width specifier, encoded in "size":

size	<V>
00	B
01	H
10	S
11	D

<n> Is the number [0-31] of the source SIMD&FP register, encoded in the "Vn" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(esize) operand1 = if AnyActiveElement(mask, esize) then V[n] else Zeros();
bits(VL) result = Z[d];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = operand1;

Z[d] = result;
```

### Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# CTERMEQ, CTERMNE

Compare and terminate loop

Detect termination conditions in serialized vector loops. Tests whether the comparison between the scalar source operands holds true and if not tests the state of the !LAST condition flag (C) which indicates whether the previous flag-setting predicate instruction selected the last element of the vector partition.

The Z and C condition flags are preserved by this instruction. The N and V condition flags are set as a pair to generate one of the following conditions for a subsequent conditional instruction:

- \* GE (N=0 & V=0): continue loop (compare failed and last element not selected);
- \* LT (N=0 & V=1): terminate loop (last element selected);
- \* LT (N=1 & V=0): terminate loop (compare succeeded);

The scalar source operands are 32-bit or 64-bit general-purpose registers of the same size.

It has encodings from 2 classes: [Equal](#) and [Not equal](#)

## Equal

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	1	sz	1	Rm					0	0	1	0	0	0	Rn					0	0	0	0	0
ne																															

CTERMEQ <R><n>, <R><m>

```
if !HaveSVE() then UNDEFINED;
integer esize = 32 << UInt(sz);
integer n = UInt(Rn);
integer m = UInt(Rm);
SVEComp op = Cmp_EQ;
```

## Not equal

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	1	sz	1	Rm					0	0	1	0	0	0	Rn					1	0	0	0	0
ne																															

CTERMNE <R><n>, <R><m>

```
if !HaveSVE() then UNDEFINED;
integer esize = 32 << UInt(sz);
integer n = UInt(Rn);
integer m = UInt(Rm);
SVEComp op = Cmp_NE;
```

## Assembler Symbols

- <R>

Is a width specifier, encoded in “sz”:

sz	<R>
0	W
1	X
- <n>

Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rn" field.
- <m>

Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
bits(esize) operand1 = X[n];
bits(esize) operand2 = X[m];
integer element1 = UInt(operand1);
integer element2 = UInt(operand2);
boolean term;

case op of
    when Cmp_EQ term = element1 == element2;
    when Cmp_NE term = element1 != element2;
if term then
    PSTATE.N = '1';
    PSTATE.V = '0';
else
    PSTATE.N = '0';
    PSTATE.V = (NOT PSTATE.C);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# DECB, DECD, DECH, DECW (scalar)

Decrement scalar by multiple of predicate constraint element count

Determines the number of active elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement the scalar destination.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 4 classes: [Byte](#) , [Doubleword](#) , [Halfword](#) and [Word](#)

## Byte

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	1	1	imm4				1	1	1	0	0	1	pattern					Rdn				
size<1>size<0>																D															

DECB <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

## Doubleword

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	1	1	1	imm4				1	1	1	0	0	1	pattern					Rdn				
size<1>size<0>																D															

DECD <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

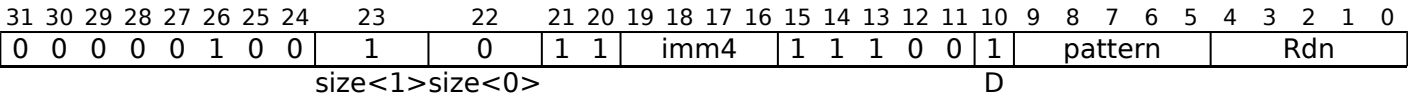
## Halfword

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1	imm4				1	1	1	0	0	1	pattern					Rdn					
size<1>size<0>																D															

DECH <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

Word



```
DECW <Xdn>{, <pattern>{, MUL #<imm>}}
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

Assembler Symbols

- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

Operation

```
CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(64) operand1 = X[dn];
X[dn] = operand1 - (count * imm);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41  
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# DECD, DECH, DECW (vector)

Decrement vector by multiple of predicate constraint element count

Determines the number of active elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement all destination vector elements.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 3 classes: [Doubleword](#) , [Halfword](#) and [Word](#)

## Doubleword

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	1	1	1	imm4				1	1	0	0	0	1	pattern					Zdn				
size<1>size<0>																D															

DECD <Zdn>.D{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

## Halfword

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1	1	imm4				1	1	0	0	0	1	pattern					Zdn				
size<1>size<0>																D															

DECH <Zdn>.H{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

## Word

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	0	1	1	imm4				1	1	0	0	0	1	pattern					Zdn				
size<1>size<0>																D															

DECW <Zdn>.S{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	P0W2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer count = DecodePredCount(pat, esize);
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    Elem[result, e, esize] = Elem[operand1, e, esize] - (count * imm);

Z[dn] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

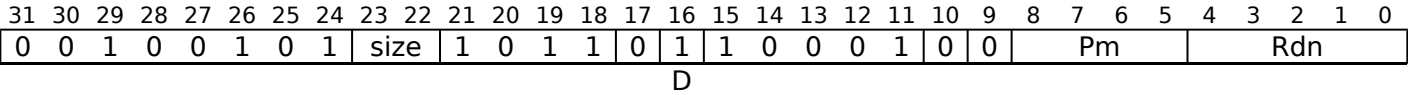
- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



# DECP (scalar)

Decrement scalar by count of true predicate elements

Counts the number of true elements in the source predicate and then uses the result to decrement the scalar destination.



DECP <Xdn>, <Pm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Rdn);
```

## Assembler Symbols

- <Xdn>Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Pm>Is the name of the source scalable predicate register, encoded in the "Pm" field.
- <T>Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) operand1 = X[dn];
bits(PL) operand2 = P[m];
integer count = 0;

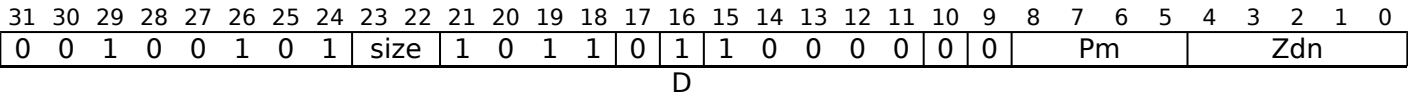
for e = 0 to elements-1
    if ElemP[operand2, e, esize] == '1' then
        count = count + 1;

X[dn] = operand1 - count;
```

# DECP (vector)

Decrement vector by count of true predicate elements

Counts the number of true elements in the source predicate and then uses the result to decrement all destination vector elements.  
The predicate size specifier may be omitted in assembler source code, but this is deprecated and will be prohibited in a future release of the architecture.



DECP <Zdn>.<T>, <Pm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Zdn);
```

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pm> Is the name of the source scalable predicate register, encoded in the "Pm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(PL) operand2 = P[m];
bits(VL) result;
integer count = 0;

for e = 0 to elements-1
    if ElemP[operand2, e, esize] == '1' then
        count = count + 1;

for e = 0 to elements-1
    Elem[result, e, esize] = Elem[operand1, e, esize] - count;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



# DUP (immediate)

Broadcast signed immediate to vector elements (unpredicated)

Unconditionally broadcast the signed integer immediate into each element of the destination vector. This instruction is unpredicated.

The immediate operand is a signed value in the range -128 to +127, and for element widths of 16 bits or higher it may also be a signed multiple of 256 in the range -32768 to +32512 (excluding 0).

The immediate is encoded in 8 bits with an optional left shift by 8. The preferred disassembly when the shift option is specified is "#<simm8>, LSL #8". However an assembler and disassembler may also allow use of the shifted 16-bit value unless the immediate is 0 and the shift amount is 8, which must be unambiguously described as "#0, LSL #8".

This instruction is used by the aliases [FMOV \(zero, unpredicated\)](#), and [MOV \(immediate, unpredicated\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	1	1	0	0	0	1	1	sh	imm8								Zd					

DUP <Zd>.<T>, #<imm>{, <shift>}

```
if !HaveSVE() then UNDEFINED;
if size:sh == '001' then UNDEFINED;
integer esize = 8 << UInt(size);
integer d = UInt(Zd);
integer imm = SInt(imm8);
if sh == '1' then imm = imm << 8;
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<imm> Is a signed immediate in the range -128 to 127, encoded in the "imm8" field.

<shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #8

## Operation

```
CheckSVEEnabled();
bits(VL) result = Replicate(imm<esize-1:0>);
Z[d] = result;
```

# DUP (scalar)

Broadcast general-purpose register to vector elements (unpredicated)

Unconditionally broadcast the general-purpose scalar source register into each element of the destination vector. This instruction is unpredicated.

This instruction is used by the alias [MOV \(scalar, unpredicated\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	0	0	0	0	0	0	1	1	1	0	Rn				Zd						

DUP <Zd>.<T>, <R><n|SP>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Rn);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<R> Is a width specifier, encoded in "size":

size	<R>
01	W
x0	W
11	X

<n|SP> Is the number [0-30] of the general-purpose source register or the name SP (31), encoded in the "Rn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) operand;
if n == 31 then
    operand = SP[];
else
    operand = X[n];
bits(VL) result;

for e = 0 to elements-1
    Elem[result, e, esize] = operand<esize-1:0>;
Z[d] = result;
```

DUP (indexed)

Broadcast indexed element to vector (unpredicated)

Unconditionally broadcast the indexed source vector element into each element of the destination vector. This instruction is unpredicated.  
The immediate element index is in the range of 0 to 63 (bytes), 31 (halfwords), 15 (words), 7 (doublewords) or 3 (quadwords). Selecting an element beyond the accessible vector length causes the destination vector to be set to zero.

This instruction is used by the alias [MOV \(SIMD&FP scalar, unpredicated\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	imm2		1	tsz					0	0	1	0	0	0	Zn					Zd				

DUP <Zd>.<T>, <Zn>.<T>[<imm>]

```
if !HaveSVE() then UNDEFINED;
bits(7) imm = imm2:tsz;
case tsz of
  when '00000' UNDEFINED;
  when '10000' esize = 128; index = UInt(imm<6:5>);
  when 'x1000' esize = 64;  index = UInt(imm<6:4>);
  when 'xx100' esize = 32;  index = UInt(imm<6:3>);
  when 'xxx10' esize = 16;  index = UInt(imm<6:2>);
  when 'xxxx1' esize = 8;   index = UInt(imm<6:1>);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "tsz":

tsz	<T>
00000	RESERVED
xxxx1	B
xxx10	H
xx100	S
x1000	D
10000	Q

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<imm> Is the immediate index, in the range 0 to one less than the number of elements in 512 bits, encoded in "imm2:tsz".

Alias Conditions

Alias	Is preferred when
<a href="#">MOV (SIMD&amp;FP scalar, unpredicated)</a>	<a href="#">BitCount</a> (imm2:tsz) == 1
<a href="#">MOV (SIMD&amp;FP scalar, unpredicated)</a>	<a href="#">BitCount</a> (imm2:tsz) > 1

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) result;
bits(esize) element;

if index >= elements then
    element = Zeros();
else
    element = Elem[operand1, index, esize];
result = Replicate(element);

Z[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

DUPM

Broadcast logical bitmask immediate to vector (unpredicated)

Unconditionally broadcast the logical bitmask immediate into each element of the destination vector. This instruction is unpredicated. The immediate is a 64-bit value consisting of a single run of ones or zeros repeating every 2, 4, 8, 16, 32 or 64 bits.

This instruction is used by the alias [MOV \(bitmask immediate\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	1	1	0	0	0	0	imm13														Zd			

DUPM <Zd>.<T>, #<const>

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer d = UInt(Zd);
bits(esize) imm;
(imm, -) = DecodeBitMasks(imm13<12>, imm13<5:0>, imm13<11:6>, TRUE);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "imm13<12>:imm13<5:0>":

imm13<12>	imm13<5:0>	<T>
0	0xxxxx	S
0	10xxxx	H
0	110xxx	B
0	1110xx	B
0	11110x	B
0	111110	RESERVED
0	111111	RESERVED
1	xxxxxx	D

<const> Is a 64, 32, 16 or 8-bit bitmask consisting of replicated 2, 4, 8, 16, 32 or 64 bit fields, each field containing a rotated run of non-zero bits, encoded in the "imm13" field.

Alias Conditions

Alias	Is preferred when
<a href="#">MOV (bitmask immediate)</a>	<a href="#">SVEMoveMaskPreferred</a> (imm13)

Operation

```
CheckSVEEnabled();
bits(VL) result = Replicate(imm);
Z[d] = result;
```



EON

Bitwise exclusive OR with inverted immediate (unpredicated)

Bitwise exclusive OR an inverted immediate with each 64-bit element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate is a 64-bit value consisting of a single run of ones or zeros repeating every 2, 4, 8, 16, 32 or 64 bits. This instruction is unpredicated.

This is a pseudo-instruction of [EOR \(immediate\)](#). This means:

- The encodings in this description are named to match the encodings of [EOR \(immediate\)](#).
- The assembler syntax is used only for assembly, and is not used on disassembly.
- The description of [EOR \(immediate\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	0	1	0	0	0	0	imm13												Zdn					

EON <Zdn>.<T>, <Zdn>.<T>, #<const>

is equivalent to

EOR <Zdn>.<T>, <Zdn>.<T>, #(-<const> - 1)

Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "imm13<12>:imm13<5:0>":

imm13<12>	imm13<5:0>	<T>
0	0xxxxx	S
0	10xxxx	H
0	110xxx	B
0	1110xx	B
0	11110x	B
0	111110	RESERVED
0	111111	RESERVED
1	xxxxxx	D

<const> Is a 64, 32, 16 or 8-bit bitmask consisting of replicated 2, 4, 8, 16, 32 or 64 bit fields, each field containing a rotated run of non-zero bits, encoded in the "imm13" field.

Operation

The description of [EOR \(immediate\)](#) gives the operational pseudocode for this instruction.

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# EOR, EORS (predicates)

Bitwise exclusive OR predicates

Bitwise exclusive OR active elements of the second source predicate with corresponding elements of the first source predicate and place the results in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Optionally sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

This instruction is used by the aliases [NOTS](#), and [NOT \(predicate\)](#).

It has encodings from 2 classes: [Not setting the condition flags](#) and [Setting the condition flags](#)

## Not setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	0	0	0	Pm				0	1	Pg				1	Pn				0	Pd			
S																															

EOR <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = FALSE;
```

## Setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	1	0	0	Pm				0	1	Pg				1	Pn				0	Pd			
S																															

EORS <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = TRUE;
```

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.
- <Pm> Is the name of the second source scalable predicate register, encoded in the "Pm" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">NOTS</a>	Pm == Pg
<a href="#">NOT (predicate)</a>	Pm == Pg

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(PL) operand1 = P[n];
bits(PL) operand2 = P[m];
bits(PL) result;

for e = 0 to elements-1
    bit element1 = ElemP[operand1, e, esize];
    bit element2 = ElemP[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        ElemP[result, e, esize] = element1 EOR element2;
    else
        ElemP[result, e, esize] = '0';

if setflags then
    PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# EOR (vectors, predicated)

Bitwise exclusive OR vectors (predicated)

Bitwise exclusive OR active elements of the second source vector with corresponding elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	0	0	1	0	0	0		Pg						Zm					Zdn	

EOR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = element1 EOR element2;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];
Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



# EOR (immediate)

Bitwise exclusive OR with immediate (unpredicated)

Bitwise exclusive OR an immediate with each 64-bit element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate is a 64-bit value consisting of a single run of ones or zeros repeating every 2, 4, 8, 16, 32 or 64 bits. This instruction is unpredicated.

This instruction is used by the pseudo-instruction [EON](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	0	1	0	0	0	0	imm13														Zdn			

EOR <Zdn>.<T>, <Zdn>.<T>, #<const>

```
if !HaveSVE() then UNDEFINED;
integer dn = UInt(Zdn);
bits(64) imm;
(imm, -) = DecodeBitMasks(imm13<12>, imm13<5:0>, imm13<11:6>, TRUE);
```

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "imm13<12>:imm13<5:0>":

imm13<12>	imm13<5:0>	<T>
0	0xxxxx	S
0	10xxxx	H
0	110xxx	B
0	1110xx	B
0	11110x	B
0	111110	RESERVED
0	111111	RESERVED
1	xxxxxx	D

<const> Is a 64, 32, 16 or 8-bit bitmask consisting of replicated 2, 4, 8, 16, 32 or 64 bit fields, each field containing a rotated run of non-zero bits, encoded in the "imm13" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV 64;
bits(VL) operand = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    bits(64) element1 = Elem[operand, e, 64];
    Elem[result, e, 64] = element1 EOR imm;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



# EOR (vectors, unpredicated)

Bitwise exclusive OR vectors (unpredicated)

Bitwise exclusive OR all elements of the second source vector with corresponding elements of the first source vector and place the results in the corresponding elements of the destination vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	0	1	Zm					0	0	1	1	0	0	Zn					Zd				

EOR <Zd>.D, <Zn>.D, <Zm>.D

```
if !HaveSVE() then UNDEFINED;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];

Z[d] = operand1 EOR operand2;
```



EORV

Bitwise exclusive OR reduction to scalar

Bitwise exclusive OR horizontally across all lanes of a vector, and place the result in the SIMD&FP scalar destination register. Inactive elements in the source vector are treated as zero.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	0	0	1	0	0	1	Pg							Zn						Vd

EORV <V><d>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D

<d> Is the number [0-31] of the destination SIMD&FP register, encoded in the "Vd" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<T> Is the size specifier, encoded in “size”:

size	<T>
00	B
01	H
10	S
11	D

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(esize) result = Zeros(esize);

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        result = result EOR Elem[operand, e, esize];

V[d] = result;
```

# EXT

Extract vector from pair of vectors

Copy the indexed byte up to the last byte of the first source vector to the bottom of the result vector, then fill the remainder of the result starting from the first byte of the second source vector. The result is placed destructively in the first source vector. This instruction is unpredicated.

An index that is greater than or equal to the vector length in bytes is treated as zero, leaving the destination and first source vector unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	0	0	1	imm8h				0	0	0	imm8l				Zm				Zdn					

EXT <Zdn>.B, <Zdn>.B, <Zm>.B, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer dn = UInt(Zdn);
integer m = UInt(Zm);
integer position = UInt(imm8h:imm8l);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <imm> Is the unsigned immediate operand, in the range 0 to 255, encoded in the "imm8h:imm8l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

if position >= elements then
    position = 0;

position = position << 3;
bits(VL*2) concat = operand2 : operand1;
result = concat<position+VL-1:position>;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

# FABD

Floating-point absolute difference (predicated)

Compute the absolute difference of active floating-point elements of the second source vector and corresponding floating-point elements of the first source vector and destructively place the result in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	1	0	0	0	1	0	0	Pg			Zm				Zdn						

FABD <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element2 = Elem[operand2, e, esize];
        Elem[result, e, esize] = FPAbs(FPSub(element1, element2, FPCR[]));
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FABS

Floating-point absolute value (predicated)

Take the absolute value of each active floating-point element of the source vector, and place the results in the corresponding elements of the destination vector. This clears the sign bit and cannot signal a floating-point exception. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	1	0	0	0	1	0	1	Pg	Zn				Zd							

FABS <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) result = Z[d];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element = Elem[operand, e, esize];
        Elem[result, e, esize] = FPAbs(element);

Z[d] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



FAC<cc>

Floating-point absolute compare vectors

Compare active absolute values of floating-point elements in the first source vector with corresponding absolute values of elements in the second source vector, and place the boolean results of the specified comparison in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Does not set the condition flags.

The <cc> symbol specifies one of the standard ARM condition codes: GE, GT, LE, or LT.

This instruction is used by the pseudo-instructions [FACLE](#), and [FACLT](#).

It has encodings from 2 classes: [Greater than](#) and [Greater than or equal](#)

Greater than

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	Zm						1	1	1	Pg			Zn				1	Pd				

FACGT <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_GT;
```

Greater than or equal

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	Zm						1	1	0	Pg			Zn				1	Pd				

FACGE <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_GE;
```

Assembler Symbols

<Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(PL) result;

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element1 = Elem[operand1, e, esize];
        bits(esize) element2 = Elem[operand2, e, esize];
        case op of
            when Cmp_GE res = FPCompareGE(FPAbs(element1), FPAbs(element2), FPCR[]);
            when Cmp_GT res = FPCompareGT(FPAbs(element1), FPAbs(element2), FPCR[]);
        ElemP[result, e, esize] = if res then '1' else '0';
    else
        ElemP[result, e, esize] = '0';

P[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



FACLE

Floating-point absolute compare less than or equal

Compare active absolute values of floating-point elements in the first source vector being less than or equal to corresponding absolute values of elements in the second source vector, and place the boolean results of the comparison in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Does not set the condition flags.

This is a pseudo-instruction of [FAC<cc>](#). This means:

- The encodings in this description are named to match the encodings of [FAC<cc>](#).
- The assembler syntax is used only for assembly, and is not used on disassembly.
- The description of [FAC<cc>](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	Zm			1	1	0	Pg			Zn			1	Pd								

FACLE <Pd>.<T>, <Pg>/Z, <Zm>.<T>, <Zn>.<T>

is equivalent to

[FACGE](#) <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

Operation

The description of [FAC<cc>](#) gives the operational pseudocode for this instruction.

# FACLT

Floating-point absolute compare less than

Compare active absolute values of floating-point elements in the first source vector being less than corresponding absolute values of elements in the second source vector, and place the boolean results of the comparison in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Does not set the condition flags.

This is a pseudo-instruction of [FAC<cc>](#). This means:

- The encodings in this description are named to match the encodings of [FAC<cc>](#).
- The assembler syntax is used only for assembly, and is not used on disassembly.
- The description of [FAC<cc>](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	Zm				1	1	1	Pg			Zn				1	Pd						

**FACLT** <Pd>.<T>, <Pg>/Z, <Zm>.<T>, <Zn>.<T>

is equivalent to

[FACGT](#) <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

## Operation

The description of [FAC<cc>](#) gives the operational pseudocode for this instruction.

# FADD (immediate)

Floating-point add immediate (predicated)

Add an immediate to each active floating-point element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate may take the value +0.5 or +1.0 only. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	1	1	0	0	1	0	1	size			0	1	1	0	0	0	1	0	0	Pg			0	0	0	0	i1	Zdn				

FADD <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <const>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
bits(esize) imm = if i1 == '0' then FPPointFive('0') else FPOne('0');
```

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<const> Is the floating-point immediate value, encoded in "i1":

i1	<const>
0	#0.5
1	#1.0

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPAAdd(element1, imm, FPCR[]);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FADD (vectors, predicated)

Floating-point add vector (predicated)

Add active floating-point elements of the second source vector to corresponding floating-point elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	0	0	0	0	1	0	0	Pg	Zm			Zdn								

FADD <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element2 = Elem[operand2, e, esize];
        Elem[result, e, esize] = FAdd(element1, element2, FPCR[]);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FADD (vectors, unpredicated)

Floating-point add vector (unpredicated)

Add all floating-point elements of the second source vector to corresponding elements of the first source vector and place the results in the corresponding elements of the destination vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size		0	Zm				0	0	0	0	0	0	Zn				Zd						

FADD <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = FPAdd(element1, element2, FPCR[]);

Z[d] = result;
```

FADDA

Floating-point add strictly-ordered reduction, accumulating in scalar

Floating-point add a SIMD&FP scalar source and all active lanes of the vector source and place the result destructively in the SIMD&FP scalar source register. Vector elements are processed strictly in order from low to high, with the scalar source providing the initial value. Inactive elements in the source vector are ignored.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size		0	1	1	0	0	0	0	0	1	Pg			Zm			Vdn						

FADDA <V><dn>, <Pg>, <V><dn>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Vdn);
integer m = UInt(Zm);
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	RESERVED
01	H
10	S
11	D

<dn> Is the number [0-31] of the source and destination SIMD&FP register, encoded in the "Vdn" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the source scalable vector register, encoded in the "Zm" field.

<T> Is the size specifier, encoded in “size”:

size	<T>
00	RESERVED
01	H
10	S
11	D

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(esize) operand1 = V[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(esize) result = operand1;

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element = Elem[operand2, e, esize];
        result = FAdd(result, element, FPCR[]);

V[dn] = result;
```



FADDV

Floating-point add recursive reduction to scalar

Floating-point add horizontally over all lanes of a vector using a recursive pairwise reduction, and place the result in the SIMD&FP scalar destination register. Inactive elements in the source vector are treated as +0.0.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	0	0	0	0	0	0	1	Pg						Zn					Vd	

FADDV <V><d>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	RESERVED
01	H
10	S
11	D

<d> Is the number [0-31] of the destination SIMD&FP register, encoded in the "Vd" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<T> Is the size specifier, encoded in “size”:

size	<T>
00	RESERVED
01	H
10	S
11	D

Operation

```
CheckSVEEnabled();
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(esize) identity = FPZero('0');
V[d] = ReducePredicated(ReduceOp_FADD, operand, mask, identity);
```

FCADD

Floating-point complex add with rotate (predicated)

Add the real and imaginary components of the active floating-point complex numbers from the first source vector to the complex numbers from the second source vector which have first been rotated by 90 or 270 degrees in the direction from the positive real axis towards the positive imaginary axis, when considered in polar representation, equivalent to multiplying the complex numbers in the second source vector by  $\pm j$  beforehand. Destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

Each complex number is represented in a vector register as an even/odd pair of elements with the real part in the even-numbered element and the imaginary part in the odd-numbered element.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	size	0	0	0	0	0	rot	1	0	0	Pg	Zm			Zdn									

FCADD <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>, <const>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean sub_i = (rot == '0');
boolean sub_r = (rot == '1');
```

Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

<const> Is the const specifier, encoded in "rot":

rot	<const>
0	#90
1	#270

## Operation

```
CheckSVEEnabled();
integer pairs = VL DIV (2 * esize);
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for p = 0 to pairs-1
    acc_r = Elem[operand1, 2 * p + 0, esize];
    acc_i = Elem[operand1, 2 * p + 1, esize];
    if ElemP[mask, 2 * p + 0, esize] == '1' then
        elt2_i = Elem[operand2, 2 * p + 1, esize];
        if sub_i then elt2_i = FPNeg(elt2_i);
        acc_r = FPAdd(acc_r, elt2_i, FPCR[]);
    if ElemP[mask, 2 * p + 1, esize] == '1' then
        elt2_r = Elem[operand2, 2 * p + 0, esize];
        if sub_r then elt2_r = FPNeg(elt2_r);
        acc_i = FPAdd(acc_i, elt2_r, FPCR[]);
    Elem[result, 2 * p + 0, esize] = acc_r;
    Elem[result, 2 * p + 1, esize] = acc_i;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FCM<cc> (zero)

Floating-point compare vector with zero

Compare active floating-point elements in the source vector with zero, and place the boolean results of the specified comparison in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Does not set the condition flags.

The <cc> symbol specifies one of the standard ARM condition codes: EQ, GE, GT, LE, LT, or NE.

It has encodings from 6 classes: [Equal](#) , [Greater than](#) , [Greater than or equal](#) , [Less than](#) , [Less than or equal](#) and [Not equal](#)

## Equal

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	1	0	0	1	0	0	0	1	Pg			Zn			0			Pd				
eq lt																	ne														

FCMEQ <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #0.0

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_EQ;
```

## Greater than

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0																			
0	1	1	0	0	1	0	1	size	0	1	0	0	0	0	0	0	1	Pg			Zn			1			Pd																							
eq																	lt																	ne																

FCMGT <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #0.0

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_GT;
```

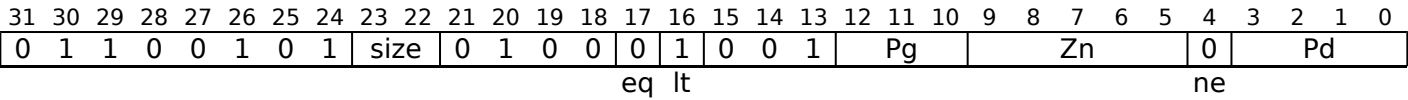
## Greater than or equal

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0										
0	1	1	0	0	1	0	1	size	0	1	0	0	0	0	0	0	0	1	Pg	Zn			0	Pd																	
eq														lt														ne													

FCMGE <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #0.0

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_GE;
```

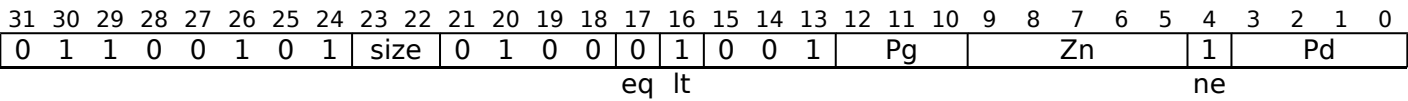
Less than



FCMLT <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #0.0

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_LT;
```

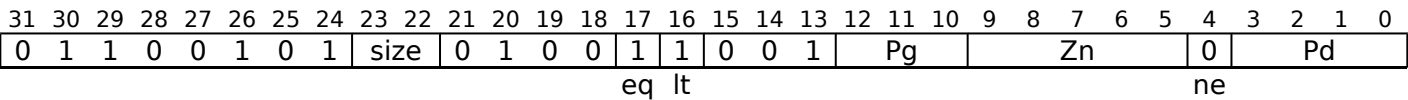
Less than or equal



FCMLE <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #0.0

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_LE;
```

Not equal



FCMNE <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #0.0

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_NE;
```

Assembler Symbols

<Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(PL) result;

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element = Elem[operand, e, esize];
        case op of
            when Cmp_EQ res = FPCompareEQ(element, 0<esize-1:0>, FPCR[]);
            when Cmp_GE res = FPCompareGE(element, 0<esize-1:0>, FPCR[]);
            when Cmp_GT res = FPCompareGT(element, 0<esize-1:0>, FPCR[]);
            when Cmp_NE res = FPCompareNE(element, 0<esize-1:0>, FPCR[]);
            when Cmp_LT res = FPCompareGT(0<esize-1:0>, element, FPCR[]);
            when Cmp_LE res = FPCompareGE(0<esize-1:0>, element, FPCR[]);
        ElemP[result, e, esize] = if res then '1' else '0';
    else
        ElemP[result, e, esize] = '0';

P[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FCM<cc> (vectors)

Floating-point compare vectors

Compare active floating-point elements in the first source vector with corresponding elements in the second source vector, and place the boolean results of the specified comparison in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Does not set the condition flags. The <cc> symbol specifies one of the standard ARM condition codes: EQ, GE, GT, or NE, with the addition of UO for an unordered comparison.

This instruction is used by the pseudo-instructions [FCMLE \(vectors\)](#), and [FCMLT \(vectors\)](#).

It has encodings from 5 classes: [Equal](#) , [Greater than](#) , [Greater than or equal](#) , [Not equal](#) and [Unordered](#)

## Equal

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	Zm			0	1	1	Pg		Zn			0	Pd									
																cmph				cmpl											

FCMEQ <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_EQ;
```

## Greater than

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	Zm				0	1	0	Pg			Zn				1	Pd						
																cmph				cmpl											

FCMGT <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_GT;
```

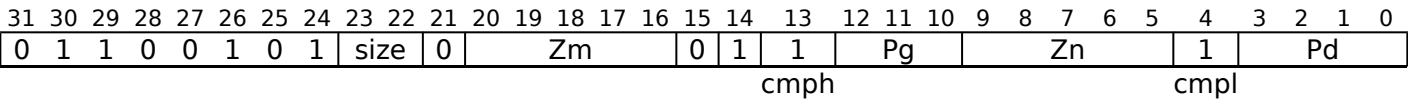
## Greater than or equal

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	Zm				0	1	0	Pg			Zn				0	Pd						
																cmph				cmpl											

FCMGE <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_GE;
```

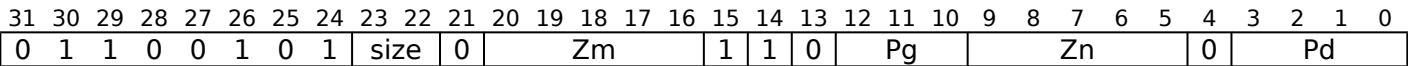
Not equal



FCMNE <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_NE;
```

Unordered



FCMUO <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_UN;
```

Assembler Symbols

<Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(PL) result;

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    case op of
      when Cmp_EQ res = FPCmpareEQ(element1, element2, FPCR[]);
      when Cmp_GE res = FPCmpareGE(element1, element2, FPCR[]);
      when Cmp_GT res = FPCmpareGT(element1, element2, FPCR[]);
      when Cmp_UN res = FPCmpareUN(element1, element2, FPCR[]);
      when Cmp_NE res = FPCmpareNE(element1, element2, FPCR[]);
      when Cmp_LT res = FPCmpareGT(element2, element1, FPCR[]);
      when Cmp_LE res = FPCmpareGE(element2, element1, FPCR[]);
    ElemP[result, e, esize] = if res then '1' else '0';
  else
    ElemP[result, e, esize] = '0';
P[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FCMLA (vectors)

Floating-point complex multiply-add with rotate (predicated)

Multiply the duplicated real components for rotations 0 and 180, or imaginary components for rotations 90 and 270, of the floating-point complex numbers in the first source vector by the corresponding complex number in the second source vector rotated by 0, 90, 180 or 270 degrees in the direction from the positive real axis towards the positive imaginary axis, when considered in polar representation. Then destructively add the products to the corresponding components of the complex numbers in the addend and destination vector, without intermediate rounding. These transformations permit the creation of a variety of multiply-add and multiply-subtract operations on complex numbers by combining two of these instructions with the same vector operands but with rotations that are 90 degrees apart. Each complex number is represented in a vector register as an even/odd pair of elements with the real part in the even-numbered element and the imaginary part in the odd-numbered element. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	size	0	Zm			0	rot	Pg		Zn			Zda											

FCMLA <Zda>.<T>, <Pg>/M, <Zn>.<T>, <Zm>.<T>, <const>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel_a = UInt(rot<0>);
integer sel_b = UInt(NOT(rot<0>));
boolean neg_i = (rot<1> == '1');
boolean neg_r = (rot<0> != rot<1>);
```

Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <const> Is the const specifier, encoded in "rot":

rot	<const>
00	#0
01	#90
10	#180
11	#270

## Operation

```
CheckSVEEnabled();
integer pairs = VL DIV (2 * esize);
bits(PL) mask = P[g];
bits(VL) operand1 = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) operand3 = Z[da];
bits(VL) result;

for p = 0 to pairs-1
    addend_r = Elem[operand3, 2 * p + 0, esize];
    addend_i = Elem[operand3, 2 * p + 1, esize];
    if ElemP[mask, 2 * p + 0, esize] == '1' then
        elt1_a = Elem[operand1, 2 * p + sel_a, esize];
        elt2_a = Elem[operand2, 2 * p + sel_a, esize];
        if neg_r then elt2_a = FPNeg(elt2_a);
        addend_r = FPMulAdd(addend_r, elt1_a, elt2_a, FPCR[]);
    if ElemP[mask, 2 * p + 1, esize] == '1' then
        elt1_a = Elem[operand1, 2 * p + sel_a, esize];
        elt2_b = Elem[operand2, 2 * p + sel_b, esize];
        if neg_i then elt2_b = FPNeg(elt2_b);
        addend_i = FPMulAdd(addend_i, elt1_a, elt2_b, FPCR[]);
    Elem[result, 2 * p + 0, esize] = addend_r;
    Elem[result, 2 * p + 1, esize] = addend_i;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## FCMLA (indexed)

Floating-point complex multiply-add by indexed values with rotate

Multiply the duplicated real components for rotations 0 and 180, or imaginary components for rotations 90 and 270, of the floating-point complex numbers in each 128-bit segment of the first source vector by the specified complex number in the corresponding the second source vector segment rotated by 0, 90, 180 or 270 degrees in the direction from the positive real axis towards the positive imaginary axis, when considered in polar representation.

Then destructively add the products to the corresponding components of the complex numbers in the addend and destination vector, without intermediate rounding.

These transformations permit the creation of a variety of multiply-add and multiply-subtract operations on complex numbers by combining two of these instructions with the same vector operands but with rotations that are 90 degrees apart.

Each complex number is represented in a vector register as an even/odd pair of elements with the real part in the even-numbered element and the imaginary part in the odd-numbered element.

The complex numbers within the second source vector are specified using an immediate index which selects the same complex number position within each 128-bit vector segment. The index range is from 0 to one less than the number of complex numbers per 128-bit segment, encoded in 1 to 2 bits depending on the size of the complex number. This instruction is unpredicated.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision](#)

### Half-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	1	0	1	i2	Zm	0	0	0	1	rot	Zn	Zda												
size<1>size<0>																															

FCMLA <Zda>.H, <Zn>.H, <Zm>.H[<imm>], <const>

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer index = UInt(i2);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel_a = UInt(rot<0>);
integer sel_b = UInt(NOT(rot<0>));
boolean neg_i = (rot<1> == '1');
boolean neg_r = (rot<0> != rot<1>);
```

### Single-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	1	1	i1	Zm	0	0	0	1	rot	Zn	Zda													
size<1>size<0>																															

FCMLA <Zda>.S, <Zn>.S, <Zm>.S[<imm>], <const>

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer index = UInt(i1);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel_a = UInt(rot<0>);
integer sel_b = UInt(NOT(rot<0>));
boolean neg_i = (rot<1> == '1');
boolean neg_r = (rot<0> != rot<1>);
```

## Assembler Symbols

<Zda>	Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
<Zn>	Is the name of the first source scalable vector register, encoded in the "Zn" field.
<Zm>	For the half-precision variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  For the single-precision variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
<imm>	For the half-precision variant: is the index of a Real and Imaginary pair, in the range 0 to 3, encoded in the "i2" field.  For the single-precision variant: is the index of a Real and Imaginary pair, in the range 0 to 1, encoded in the "i1" field.
<const>	Is the const specifier, encoded in "rot":

rot	<const>
00	#0
01	#90
10	#180
11	#270

## Operation

```
CheckSVEEnabled();
integer pairs = VL DIV (2 * esize);
integer pairspersegment = 128 DIV (2 * esize);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for p = 0 to pairs-1
    segmentbase = p - (p MOD pairspersegment);
    s = segmentbase + index;
    addend_r = Elem[operand3, 2 * p + 0, esize];
    addend_i = Elem[operand3, 2 * p + 1, esize];
    elt1_a = Elem[operand1, 2 * p + sel_a, esize];
    elt2_a = Elem[operand2, 2 * s + sel_a, esize];
    elt2_b = Elem[operand2, 2 * s + sel_b, esize];
    if neg_r then elt2_a = FPNeg(elt2_a);
    if neg_i then elt2_b = FPNeg(elt2_b);
    addend_r = FPMulAdd(addend_r, elt1_a, elt2_a, FPCR[]);
    addend_i = FPMulAdd(addend_i, elt1_a, elt2_b, FPCR[]);
    Elem[result, 2 * p + 0, esize] = addend_r;
    Elem[result, 2 * p + 1, esize] = addend_i;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

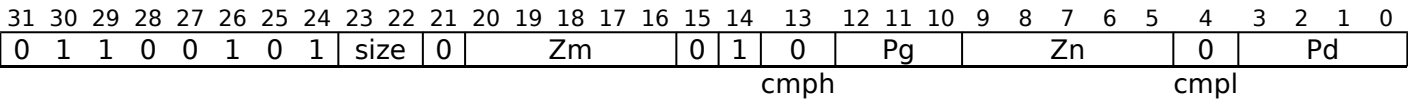
# FCMLE (vectors)

Floating-point compare less than or equal to vector

Compare active floating-point elements in the first source vector being less than or equal to corresponding elements in the second source vector, and place the boolean results of the comparison in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Does not set the condition flags.

This is a pseudo-instruction of [FCM<cc> \(vectors\)](#). This means:

- The encodings in this description are named to match the encodings of [FCM<cc> \(vectors\)](#).
- The assembler syntax is used only for assembly, and is not used on disassembly.
- The description of [FCM<cc> \(vectors\)](#) gives the operational pseudocode for this instruction.



FCMLE <Pd>.<T>, <Pg>/Z, <Zm>.<T>, <Zn>.<T>

is equivalent to

FCMGE <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

## Operation

The description of [FCM<cc> \(vectors\)](#) gives the operational pseudocode for this instruction.

# FCMLT (vectors)

Floating-point compare less than vector

Compare active floating-point elements in the first source vector being less than corresponding elements in the second source vector, and place the boolean results of the comparison in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Does not set the condition flags.

This is a pseudo-instruction of [FCM<cc> \(vectors\)](#). This means:

- The encodings in this description are named to match the encodings of [FCM<cc> \(vectors\)](#).
- The assembler syntax is used only for assembly, and is not used on disassembly.
- The description of [FCM<cc> \(vectors\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	Zm				0	1	0	Pg				Zn				1	Pd					
cmph																cmpl															

FCMLT <Pd>.<T>, <Pg>/Z, <Zm>.<T>, <Zn>.<T>

is equivalent to

FCMGT <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

## Assembler Symbols

- <Pd>
- Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Zm>
- Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <Zn>
- Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <T>
- Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg>
- Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

## Operation

The description of [FCM<cc> \(vectors\)](#) gives the operational pseudocode for this instruction.

FCPY

Copy 8-bit floating-point immediate to vector elements (predicated)

Copy a floating-point immediate into each active element in the destination vector. Inactive elements in the destination vector register remain unmodified.

This instruction is used by the alias [FMOV \(immediate, predicated\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size		0	1	Pg				1	1	0	imm8								Zd				

FCPY <Zd>.<T>, <Pg>/M, #<const>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer d = UInt(Zd);
bits(esize) imm = VFPEExpandImm(imm8);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.

<const> Is a floating-point immediate value expressable as  $\pm n \div 16 \times 2^r$ , where n and r are integers such that  $16 \leq n \leq 31$  and  $-3 \leq r \leq 4$ , i.e. a normalized binary floating-point encoding with 1 sign bit, 3-bit exponent, and 4-bit fractional part, encoded in the "imm8" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) result = Z[d];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = imm;

Z[d] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.





# FCVT

Floating-point convert precision (predicated)

Convert the size and precision of each active floating-point element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

Since the input and result types have a different size the smaller type is held unpacked in the least significant bits of elements of the larger size. When the input is the smaller type the upper bits of each source element are ignored. When the result is the smaller type the results are zero-extended to fill each destination element.

It has encodings from 6 classes: [Half-precision to single-precision](#) , [Half-precision to double-precision](#) , [Single-precision to half-precision](#) , [Single-precision to double-precision](#) , [Double-precision to half-precision](#) and [Double-precision to single-precision](#)

## Half-precision to single-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	1	0	0	0	1	0	0	1	1	0	1	Pg			Zn			Zd						

FCVT [<Zd>.S](#), [<Pg>/M](#), [<Zn>.H](#)

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 16;
integer d_esize = 32;
```

## Half-precision to double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	1	1	0	0	1	0	0	1	1	0	1	Pg			Zn			Zd						

FCVT [<Zd>.D](#), [<Pg>/M](#), [<Zn>.H](#)

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 16;
integer d_esize = 64;
```

## Single-precision to half-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	1	0	0	0	1	0	0	0	1	0	1	Pg			Zn			Zd						

FCVT [<Zd>.H](#), [<Pg>/M](#), [<Zn>.S](#)

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 32;
integer d_esize = 16;
```

Single-precision to double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	1	1	0	0	1	0	1	1	1	0	1	Pg			Zn				Zd					

FCVT <Zd>.D, <Pg>/M, <Zn>.S

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esign = 32;
integer d_esign = 64;
```

Double-precision to half-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	1	1	0	0	1	0	0	0	1	0	1	Pg			Zn				Zd					

FCVT <Zd>.H, <Pg>/M, <Zn>.D

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esign = 64;
integer d_esign = 16;
```

Double-precision to single-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	1	1	0	0	1	0	1	0	1	0	1	Pg			Zn				Zd					

FCVT <Zd>.S, <Pg>/M, <Zn>.D

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esign = 64;
integer d_esign = 32;
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) result = Z[d];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element = Elem[operand, e, esize];
        bits(d_esize) res = FPConvertSVE(element<s_esize-1:0>, FPCR[]);
        Elem[result, e, esize] = ZeroExtend(res);

Z[d] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FCVTZS

Floating-point convert to signed integer, rounding toward zero (predicated)

Convert to the signed integer nearer to zero from each active floating-point element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

If the input and result types have a different size the smaller type is held unpacked in the least significant bits of elements of the larger size. When the input is the smaller type the upper bits of each source element are ignored. When the result is the smaller type the results are sign-extended to fill each destination element.

It has encodings from 7 classes: [Half-precision to 16-bit](#) , [Half-precision to 32-bit](#) , [Half-precision to 64-bit](#) , [Single-precision to 32-bit](#) , [Single-precision to 64-bit](#) , [Double-precision to 32-bit](#) and [Double-precision to 64-bit](#)

## Half-precision to 16-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	0	1	0	1	1	0	1	0	1	0	1	Pg			Zn			Zd						
int U																															

FCVTZS <Zd>.H, <Pg>/M, <Zn>.H

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 16;
integer d_esize = 16;
boolean unsigned = FALSE;
FPRounding rounding = FPRounding_ZERO;
```

## Half-precision to 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	0	1	0	1	1	1	0	0	1	0	1	Pg			Zn			Zd						
int_U																															

FCVTZS <Zd>.S, <Pg>/M, <Zn>.H

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 16;
integer d_esize = 32;
boolean unsigned = FALSE;
FPRounding rounding = FPRounding_ZERO;
```

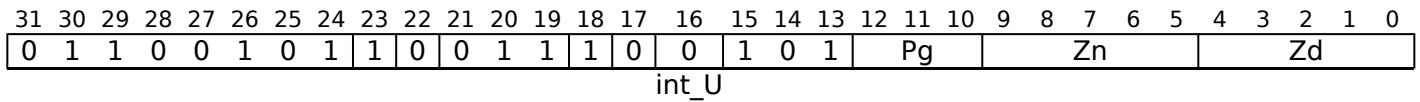
## Half-precision to 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	0	1	0	1	1	1	1	0	1	0	1	Pg			Zn			Zd						
int U																															

FCVTZS <Zd>.D, <Pg>/M, <Zn>.H

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 16;
integer d_esize = 64;
boolean unsigned = FALSE;
FPRounding rounding = FPRounding_ZERO;
```

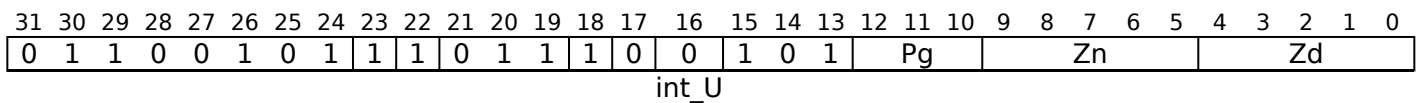
### Single-precision to 32-bit



FCVTZS <Zd>.S, <Pg>/M, <Zn>.S

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 32;
integer d_esize = 32;
boolean unsigned = FALSE;
FPRounding rounding = FPRounding_ZERO;
```

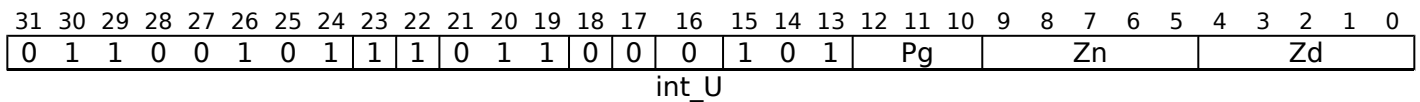
### Single-precision to 64-bit



FCVTZS <Zd>.D, <Pg>/M, <Zn>.S

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 32;
integer d_esize = 64;
boolean unsigned = FALSE;
FPRounding rounding = FPRounding_ZERO;
```

### Double-precision to 32-bit



FCVTZS <Zd>.S, <Pg>/M, <Zn>.D

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 64;
integer d_esize = 32;
boolean unsigned = FALSE;
FPRounding rounding = FPRounding_ZERO;
```

## Double-precision to 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	1	1	0	1	1	1	1	0	1	0	1	Pg			Zn			Zd						

int\_U

FCVTZS <Zd>.D, <Pg>/M, <Zn>.D

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 64;
integer d_esize = 64;
boolean unsigned = FALSE;
FPRounding rounding = FPRounding_ZERO;
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) result = Z[d];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element = Elem[operand, e, esize];
        bits(d_esize) res = FPToFixed(element<s_esize-1:0>, 0, unsigned, FPCR[], rounding);
        Elem[result, e, esize] = Extend(res, unsigned);

Z[d] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.





# FCVTZU

Floating-point convert to unsigned integer, rounding toward zero (predicated)

Convert to the unsigned integer nearer to zero from each active floating-point element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

If the input and result types have a different size the smaller type is held unpacked in the least significant bits of elements of the larger size. When the input is the smaller type the upper bits of each source element are ignored. When the result is the smaller type the results are zero-extended to fill each destination element.

It has encodings from 7 classes: [Half-precision to 16-bit](#) , [Half-precision to 32-bit](#) , [Half-precision to 64-bit](#) , [Single-precision to 32-bit](#) , [Single-precision to 64-bit](#) , [Double-precision to 32-bit](#) and [Double-precision to 64-bit](#)

## Half-precision to 16-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	0	1	0	1	1	0	1	1	1	0	1	Pg			Zn				Zd					
int U																															

FCVTZU <Zd>.H, <Pg>/M, <Zn>.H

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 16;
integer d_esize = 16;
boolean unsigned = TRUE;
FPRounding rounding = FPRounding_ZERO;
```

## Half-precision to 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	0	1	0	1	1	1	0	1	1	0	1	Pg			Zn				Zd					
int_U																															

FCVTZU <Zd>.S, <Pg>/M, <Zn>.H

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 16;
integer d_esize = 32;
boolean unsigned = TRUE;
FPRounding rounding = FPRounding_ZERO;
```

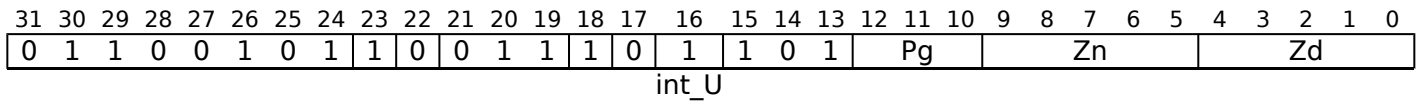
## Half-precision to 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	0	1	0	1	1	1	1	1	1	0	1	Pg			Zn				Zd					
int U																															

FCVTZU <Zd>.D, <Pg>/M, <Zn>.H

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 16;
integer d_esize = 64;
boolean unsigned = TRUE;
FPRounding rounding = FPRounding_ZERO;
```

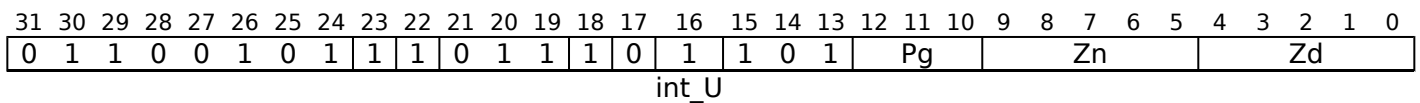
### Single-precision to 32-bit



FCVTZU <Zd>.S, <Pg>/M, <Zn>.S

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 32;
integer d_esize = 32;
boolean unsigned = TRUE;
FPRounding rounding = FPRounding_ZERO;
```

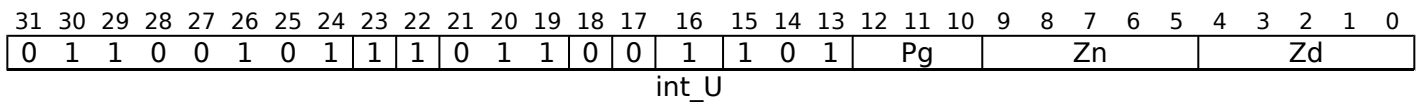
### Single-precision to 64-bit



FCVTZU <Zd>.D, <Pg>/M, <Zn>.S

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 32;
integer d_esize = 64;
boolean unsigned = TRUE;
FPRounding rounding = FPRounding_ZERO;
```

### Double-precision to 32-bit



FCVTZU <Zd>.S, <Pg>/M, <Zn>.D

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 64;
integer d_esize = 32;
boolean unsigned = TRUE;
FPRounding rounding = FPRounding_ZERO;
```

## Double-precision to 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	1	1	0	1	1	1	1	1	1	0	1	Pg			Zn			Zd						
int_U																															

FCVTZU <Zd>.D, <Pg>/M, <Zn>.D

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 64;
integer d_esize = 64;
boolean unsigned = TRUE;
FPRounding rounding = FPRounding_ZERO;
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) result = Z[d];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element = Elem[operand, e, esize];
        bits(d_esize) res = FPToFixed(element<s_esize-1:0>, 0, unsigned, FPCR[], rounding);
        Elem[result, e, esize] = Extend(res, unsigned);

Z[d] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



# FDIV

Floating-point divide by vector (predicated)

Divide active floating-point elements of the first source vector by corresponding floating-point elements of the second source vector and destructively place the quotient in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	1	1	0	1	1	0	0	Pg	Zm				Zdn								

FDIV <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element2 = Elem[operand2, e, esize];
        Elem[result, e, esize] = FPDiv(element1, element2, FPCR[]);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FDIVR

Floating-point reversed divide by vector (predicated)

Reversed divide active floating-point elements of the second source vector by corresponding floating-point elements of the first source vector and destructively place the quotient in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	1	1	0	0	1	0	0	Pg				Zm				Zdn					

FDIVR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element2 = Elem[operand2, e, esize];
        Elem[result, e, esize] = FPDiv(element2, element1, FPCR[]);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



FDUP

Broadcast 8-bit floating-point immediate to vector elements (unpredicated)

Unconditionally broadcast the floating-point immediate into each element of the destination vector. This instruction is unpredicated.

This instruction is used by the alias [FMOV \(immediate, unpredicated\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	1	1	0	0	1	1	1	0	imm8								Zd					

FDUP <Zd>.<T>, #<const>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer d = UInt(Zd);
bits(esize) imm = VFPEExpandImm(imm8);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<const> Is a floating-point immediate value expressable as  $\pm n \div 16 \times 2^r$ , where n and r are integers such that  $16 \leq n \leq 31$  and  $-3 \leq r \leq 4$ , i.e. a normalized binary floating-point encoding with 1 sign bit, 3-bit exponent, and 4-bit fractional part, encoded in the "imm8" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) result;

for e = 0 to elements-1
    Elem[result, e, esize] = imm;

Z[d] = result;
```

FEXPA

Floating-point exponential accelerator

The FEXPA instruction accelerates the polynomial series calculation of the EXP(x) function.

The double-precision variant copies the low 52 bits of an entry from a hard-wired table of 64-bit coefficients, indexed by the low 6 bits of each element of the source vector, and prepends to that the next 11 bits of the source element (src<16:6>), setting the sign bit to zero.

The single-precision variant copies the low 23 bits of an entry from hard-wired table of 32-bit coefficients, indexed by the low 6 bits of each element of the source vector, and prepends to that the next 8 bits of the source element (src<13:6>), setting the sign bit to zero.

The half-precision variant copies the low 10 bits of an entry from hard-wired table of 16-bit coefficients, indexed by the low 5 bits of each element of the source vector, and prepends to that the next 5 bits of the source element (src<9:5>), setting the sign bit to zero.

A coefficient table entry with index m holds the floating-point value  $2^{(m/64)}$ , or for the half-precision variant  $2^{(m/32)}$ . This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1	0	0	0	0	0	0	1	0	1	1	1	0	Zn					Zd				

FEXPA <Zd>.<T>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand = Z[n];
bits(VL) result;

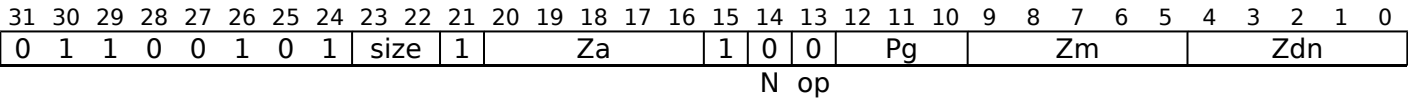
for e = 0 to elements-1
    bits(esize) element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPExpA(element);

Z[d] = result;
```

FMAD

Floating-point fused multiply-add vectors (predicated), writing multiplicand [ $Z_{dn} = Z_a + Z_{dn} * Z_m$ ]

Multiply the corresponding active floating-point elements of the first and second source vectors and add to elements of the third (addend) vector without intermediate rounding. Destructively place the results in the destination and first source (multiplicand) vector. Inactive elements in the destination vector register remain unmodified.



FMAD <Zdn>.<T>, <Pg>/M, <Zm>.<T>, <Za>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
integer a = UInt(Za);
boolean op1_neg = FALSE;
boolean op3_neg = FALSE;
```

Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

<Za> Is the name of the third source scalable vector register, encoded in the "Za" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) operand3 = if AnyActiveElement(mask, esize) then Z[a] else Zeros();
bits(VL) result;

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    bits(esize) element3 = Elem[operand3, e, esize];

    if op1_neg then element1 = FPNeg(element1);
    if op3_neg then element3 = FPNeg(element3);
    Elem[result, e, esize] = FPMulAdd(element3, element1, element2, FPCR[]);
  else
    Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FMAX (immediate)

Floating-point maximum with immediate (predicated)

Determine the maximum of an immediate and each active floating-point element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate may take the value +0.0 or +1.0 only. If the element value is NaN then the result is NaN. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	1	1	1	1	0	1	0	0	Pg	0	0	0	0	i1	Zdn							

FMAX <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <const>

```

if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
bits(esize) imm = if i1 == '0' then Zeros() else FP0ne('0');
```

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<const> Is the floating-point immediate value, encoded in "i1":

i1	<const>
0	#0.0
1	#1.0

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPMMax(element1, imm, FPCR[]);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FMAX (vectors)

Floating-point maximum (predicated)

Determine the maximum of active floating-point elements of the second source vector and corresponding floating-point elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. If one element value is numeric and the other is a quiet NaN, then the result is the numeric value. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	1	1	0	1	0	0	Pg	Zm					Zdn							

FMAX <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```

if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);

```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element2 = Elem[operand2, e, esize];
        Elem[result, e, esize] = FPMAX(element1, element2, FPCR[]);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;

```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# FMAXNM (immediate)

Floating-point maximum number with immediate (predicated)

Determine the maximum number value of an immediate and each active floating-point element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate may take the value +0.0 or +1.0 only. If the element value is a quiet NaN, then the result is the immediate. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	1	1	1	0	0	0	1	0	0	Pg	0	0	0	0	i1							Zdn

FMAXNM <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <const>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
bits(esize) imm = if i1 == '0' then Zeros() else FP0ne('0');
```

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<const> Is the floating-point immediate value, encoded in "i1":

i1	<const>
0	#0.0
1	#1.0

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPMaxNum(element1, imm, FPCR[]);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FMAXNM (vectors)

Floating-point maximum number (predicated)

Determine the maximum number value of active floating-point elements of the second source vector and corresponding floating-point elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. If one element value is NaN then the result is the numeric value. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	1	0	0	0	1	0	0	Pg												

FMAXNM <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```

if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);

```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element2 = Elem[operand2, e, esize];
        Elem[result, e, esize] = FPMaXNum(element1, element2, FPCR[]);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;

```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

**FMAXNMV**

Floating-point maximum number recursive reduction to scalar

Floating-point maximum number horizontally over all lanes of a vector using a recursive pairwise reduction, and place the result in the SIMD&FP scalar destination register. Inactive elements in the source vector are treated as the default NaN.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	1	0	0	0	1	Pg		Zn				Vd								

**FMAXNMV** <V><d>, <Pg>, <Zn>.<T>

```

if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);

```

**Assembler Symbols**

<V> Is a width specifier, encoded in “size”:

size	<V>
00	RESERVED
01	H
10	S
11	D

<d> Is the number [0-31] of the destination SIMD&FP register, encoded in the "Vd" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<T> Is the size specifier, encoded in “size”:

size	<T>
00	RESERVED
01	H
10	S
11	D

**Operation**

```

CheckSVEEnabled();
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(esize) identity = FPDefaultNaN();

V[d] = ReducePredicated(ReduceOp_FMAXNUM, operand, mask, identity);

```

FMAXV

Floating-point maximum recursive reduction to scalar

Floating-point maximum horizontally over all lanes of a vector using a recursive pairwise reduction, and place the result in the SIMD&FP scalar destination register. Inactive elements in the source vector are treated as -Infinity.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	1	1	0	0	0	1	Pg							Zn					Vd	

FMAXV <V><d>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	RESERVED
01	H
10	S
11	D

<d> Is the number [0-31] of the destination SIMD&FP register, encoded in the "Vd" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<T> Is the size specifier, encoded in “size”:

size	<T>
00	RESERVED
01	H
10	S
11	D

Operation

```
CheckSVEEnabled();
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(esize) identity = FPInfinity('1');
V[d] = ReducePredicated(ReduceOp_FMAX, operand, mask, identity);
```

# FMIN (immediate)

Floating-point minimum with immediate (predicated)

Determine the minimum of an immediate and each active floating-point element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate may take the value +0.0 or +1.0 only. If the element value is NaN then the result is NaN. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	1	1	1	1	1	1	0	0	Pg	0	0	0	0	i1	Zdn							

FMIN <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <const>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
bits(esize) imm = if i1 == '0' then Zeros() else FP0ne('0');
```

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<const> Is the floating-point immediate value, encoded in "i1":

i1	<const>
0	#0.0
1	#1.0

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPMIn(element1, imm, FPCR[]);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# FMIN (vectors)

Floating-point minimum (predicated)

Determine the minimum of active floating-point elements of the second source vector and corresponding floating-point elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. If the element value is a quiet NaN, then the result is the immediate. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	1	1	1	1	0	0	Pg				Zm				Zdn					

FMIN <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element2 = Elem[operand2, e, esize];
        Elem[result, e, esize] = FPMIn(element1, element2, FPCR[]);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FMINNM (immediate)

Floating-point minimum number with immediate (predicated)

Determine the minimum number value of an immediate and each active floating-point element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate may take the value +0.0 or +1.0 only. If one element value is numeric and the other is a quiet NaN, then the result is the numeric value. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	1	1	1	0	1	1	0	0	Pg	0	0	0	0	i1	Zdn							

FMINNM <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <const>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
bits(esize) imm = if i1 == '0' then Zeros() else FP0ne('0');
```

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<const> Is the floating-point immediate value, encoded in "i1":

i1	<const>
0	#0.0
1	#1.0

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPMinNum(element1, imm, FPCR[]);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FMINNM (vectors)

Floating-point minimum number (predicated)

Determine the minimum number value of active floating-point elements of the second source vector and corresponding floating-point elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. If one element value is numeric and the other is a quiet NaN, then the result is the numeric value. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	1	0	1	1	0	0	Pg			Zm					Zdn					

FMINNM <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element2 = Elem[operand2, e, esize];
        Elem[result, e, esize] = FPMinNum(element1, element2, FPCR[]);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FMINNMV

Floating-point minimum number recursive reduction to scalar

Floating-point minimum number horizontally over all lanes of a vector using a recursive pairwise reduction, and place the result in the SIMD&FP scalar destination register. Inactive elements in the source vector are treated as the default NaN.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	1	0	1	0	0	1	Pg			Zn			Vd							

FMINNMV <V><d>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	RESERVED
01	H
10	S
11	D

<d> Is the number [0-31] of the destination SIMD&FP register, encoded in the "Vd" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<T> Is the size specifier, encoded in “size”:

size	<T>
00	RESERVED
01	H
10	S
11	D

Operation

```
CheckSVEEnabled();
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(esize) identity = FPDefaultNaN();

V[d] = ReducePredicated(ReduceOp_FMINNUM, operand, mask, identity);
```

FMINV

Floating-point minimum recursive reduction to scalar

Floating-point minimum horizontally over all lanes of a vector using a recursive pairwise reduction, and place the result in the SIMD&FP scalar destination register. Inactive elements in the source vector are treated as +Infinity.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	1	1	1	0	0	1	Pg							Zn					Vd	

FMINV <V><d>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	RESERVED
01	H
10	S
11	D

<d> Is the number [0-31] of the destination SIMD&FP register, encoded in the "Vd" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<T> Is the size specifier, encoded in “size”:

size	<T>
00	RESERVED
01	H
10	S
11	D

Operation

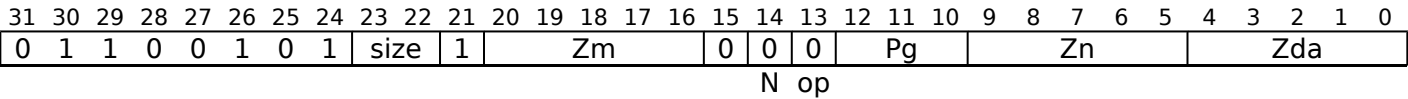
```
CheckSVEEnabled();
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(esize) identity = FPInfinity('0');
V[d] = ReducePredicated(ReduceOp_FMIN, operand, mask, identity);
```



FMLA (vectors)

Floating-point fused multiply-add vectors (predicated), writing addend [Zda = Zda + Zn \* Zm]

Multiply the corresponding active floating-point elements of the first and second source vectors and add to elements of the third source (addend) vector without intermediate rounding. Destructively place the results in the destination and third source (addend) vector. Inactive elements in the destination vector register remain unmodified.



FMLA <Zda>.<T>, <Pg>/M, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean op1_neg = FALSE;
boolean op3_neg = FALSE;
```

Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    bits(esize) element3 = Elem[operand3, e, esize];

    if op1_neg then element1 = FPNeg(element1);
    if op3_neg then element3 = FPNeg(element3);
    Elem[result, e, esize] = FPMulAdd(element3, element1, element2, FPCR[]);
  else
    Elem[result, e, esize] = Elem[operand3, e, esize];

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FMLA (indexed)

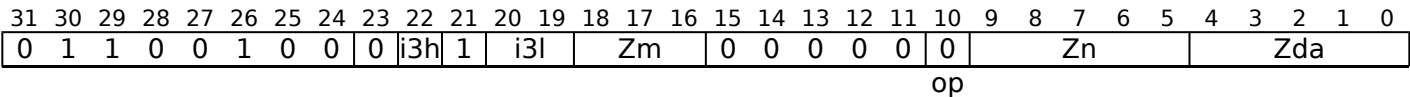
Floating-point fused multiply-add by indexed elements ( $Zda = Zda + Zn * Zm[indexed]$ )

Multiply all floating-point elements within each 128-bit segment of the first source vector by the specified element in the corresponding second source vector segment. The products are then destructively added without intermediate rounding to the corresponding elements of the addend and destination vector.

The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 1 to 3 bits depending on the size of the element. This instruction is unpredicated.

It has encodings from 3 classes: [Half-precision](#) , [Single-precision](#) and [Double-precision](#)

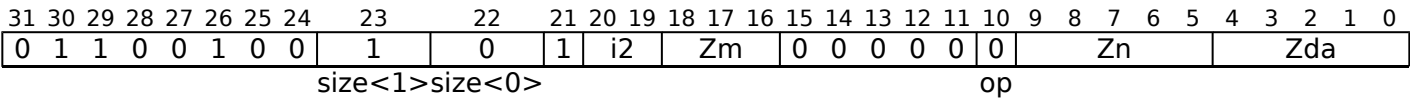
## Half-precision



FMLA <Zda>.H, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean op1_neg = FALSE;
boolean op3_neg = FALSE;
```

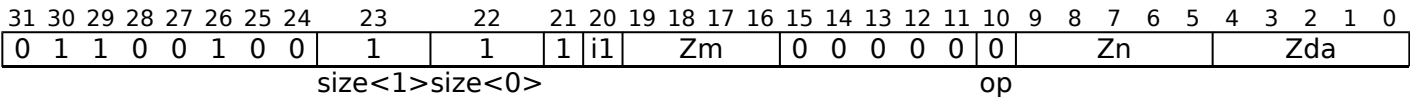
## Single-precision



FMLA <Zda>.S, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean op1_neg = FALSE;
boolean op3_neg = FALSE;
```

## Double-precision



FMLA <Zda>.D, <Zn>.D, <Zm>.D[<imm>]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer index = UInt(i1);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean op1_neg = FALSE;
boolean op3_neg = FALSE;
```

## Assembler Symbols

<Zda>	Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
<Zn>	Is the name of the first source scalable vector register, encoded in the "Zn" field.
<Zm>	For the half-precision and single-precision variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  For the double-precision variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
<imm>	For the half-precision variant: is the immediate index, in the range 0 to 7, encoded in the "i3h:i3l" fields.  For the single-precision variant: is the immediate index, in the range 0 to 3, encoded in the "i2" field.  For the double-precision variant: is the immediate index, in the range 0 to 1, encoded in the "i1" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer eltspersegment = 128 DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltspersegment);
    integer s = segmentbase + index;
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, s, esize];
    bits(esize) element3 = Elem[result, e, esize];
    if op1_neg then element1 = FPNeg(element1);
    if op3_neg then element3 = FPNeg(element3);
    Elem[result, e, esize] = FPMulAdd(element3, element1, element2, FPCR[]);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

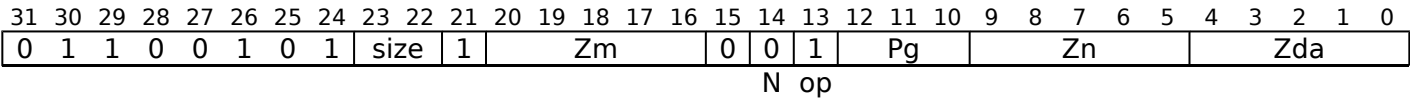
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FMLS (vectors)

Floating-point fused multiply-subtract vectors (predicated), writing addend [Zda = Zda + -Zn \* Zm]

Multiply the corresponding active floating-point elements of the first and second source vectors and subtract from elements of the third source (addend) vector without intermediate rounding. Destructively place the results in the destination and third source (addend) vector. Inactive elements in the destination vector register remain unmodified.



```
FMLS <Zda>.<T>, <Pg>/M, <Zn>.<T>, <Zm>.<T>
```

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean op1_neg = TRUE;
boolean op3_neg = FALSE;
```

## Assembler Symbols

<Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    bits(esize) element3 = Elem[operand3, e, esize];

    if op1_neg then element1 = FPNeg(element1);
    if op3_neg then element3 = FPNeg(element3);
    Elem[result, e, esize] = FPMulAdd(element3, element1, element2, FPCR[]);
  else
    Elem[result, e, esize] = Elem[operand3, e, esize];

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FMLS (indexed)

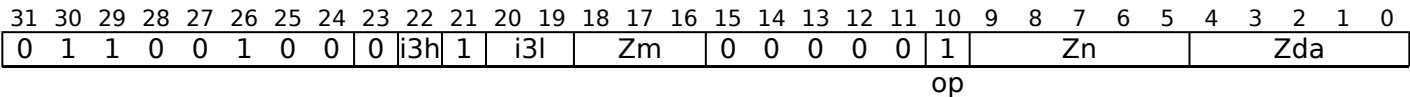
Floating-point fused multiply-subtract by indexed elements ( $Zda = Zda + -Zn * Zm[indexed]$ )

Multiply all floating-point elements within each 128-bit segment of the first source vector by the specified element in the corresponding second source vector segment. The products are then destructively subtracted without intermediate rounding from the corresponding elements of the addend and destination vector.

The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 1 to 3 bits depending on the size of the element. This instruction is unpredicated.

It has encodings from 3 classes: [Half-precision](#) , [Single-precision](#) and [Double-precision](#)

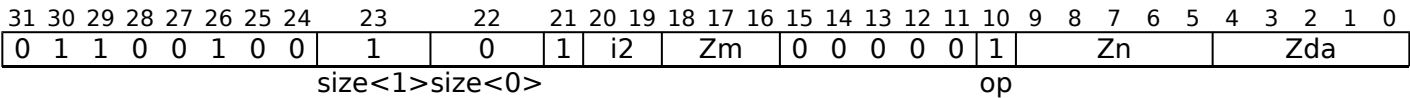
## Half-precision



FMLS <Zda>.H, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean op1_neg = TRUE;
boolean op3_neg = FALSE;
```

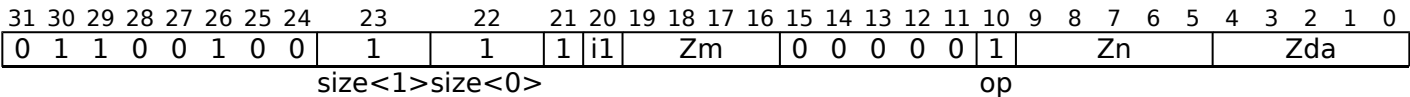
## Single-precision



FMLS <Zda>.S, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean op1_neg = TRUE;
boolean op3_neg = FALSE;
```

## Double-precision



FMLS <Zda>.D, <Zn>.D, <Zm>.D[<imm>]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer index = UInt(i1);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean op1_neg = TRUE;
boolean op3_neg = FALSE;
```

## Assembler Symbols

<Zda>	Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
<Zn>	Is the name of the first source scalable vector register, encoded in the "Zn" field.
<Zm>	For the half-precision and single-precision variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  For the double-precision variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
<imm>	For the half-precision variant: is the immediate index, in the range 0 to 7, encoded in the "i3h:i3l" fields.  For the single-precision variant: is the immediate index, in the range 0 to 3, encoded in the "i2" field.  For the double-precision variant: is the immediate index, in the range 0 to 1, encoded in the "i1" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer eltspersegment = 128 DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltspersegment);
    integer s = segmentbase + index;
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, s, esize];
    bits(esize) element3 = Elem[result, e, esize];
    if op1_neg then element1 = FPNeg(element1);
    if op3_neg then element3 = FPNeg(element3);
    Elem[result, e, esize] = FPMulAdd(element3, element1, element2, FPCR[]);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# FMMLA

Floating-point matrix multiply-accumulate

The floating-point matrix multiply-accumulate instruction supports single-precision and double-precision data types in a 2×2 matrix contained in segments of 128 or 256 bits, respectively. It multiplies the 2×2 matrix in each segment of the first source vector by the 2×2 matrix in the corresponding segment of the second source vector. The resulting 2×2 matrix product is then destructively added to the matrix accumulator held in the corresponding segment of the addend and destination vector. This is equivalent to performing a 2-way dot product per destination element. This instruction is unpredicated. The single-precision variant is vector length agnostic. The double-precision variant requires that the current vector length is at least 256 bits, and if the current vector length is not an integer multiple of 256 bits then the trailing bits are set to zero.

ID\_AA64ZFR0\_EL1.F32MM indicates whether the single-precision variant is implemented.

ID\_AA64ZFR0\_EL1.F64MM indicates whether the double-precision variant is implemented.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

## 32-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	1	0	1	Zm					1	1	1	0	0	1	Zn					Zda				

FMMLA <Zda>.S, <Zn>.S, <Zm>.S

```
if !HaveSVEFP32MatMulExt() then UNDEFINED;
integer esize = 32;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## 64-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	1	1	1	Zm					1	1	1	0	0	1	Zn					Zda				

FMMLA <Zda>.D, <Zn>.D, <Zm>.D

```
if !HaveSVEFP64MatMulExt() then UNDEFINED;
integer esize = 64;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
if VL < esize * 4 then UNDEFINED;
integer segments = VL DIV (4 * esize);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result = Zeros();
bits(4*esize) op1, op2;
bits(4*esize) res, addend;

for s = 0 to segments-1
    op1    = Elem[operand1, s, 4*esize];
    op2    = Elem[operand2, s, 4*esize];
    addend = Elem[operand3, s, 4*esize];
    res    = FPMatMulAdd(addend, op1, op2, esize, FPCR[]);
    Elem[result, s, 4*esize] = res;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FMOV (zero, predicated)

Move floating-point +0.0 to vector elements (predicated)

Move floating-point constant +0.0 to to each active element in the destination vector. Inactive elements in the destination vector register remain unmodified.

This is a pseudo-instruction of [CPY \(immediate, merging\)](#). This means:

- The encodings in this description are named to match the encodings of [CPY \(immediate, merging\)](#).
- The assembler syntax is used only for assembly, and is not used on disassembly.
- The description of [CPY \(immediate, merging\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size		0	1	Pg				0	1	0	0	0	0	0	0	0	0	0	Zd				
M sh																imm8															

**FMOV** <Zd>.<T>, <Pg>/M, #0.0

is equivalent to

**CPY** <Zd>.<T>, <Pg>/M, #0

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.

## Operation

The description of [CPY \(immediate, merging\)](#) gives the operational pseudocode for this instruction.

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FMOV (zero, unpredicated)

Move floating-point +0.0 to vector elements (unpredicated)

Unconditionally broadcast the floating-point constant +0.0 into each element of the destination vector. This instruction is unpredicated.

This is a pseudo-instruction of [DUP \(immediate\)](#). This means:

- The encodings in this description are named to match the encodings of [DUP \(immediate\)](#).
- The assembler syntax is used only for assembly, and is not used on disassembly.
- The description of [DUP \(immediate\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	Zd			
sh																imm8															

FMOV <Zd>.<T>, #0.0

is equivalent to

[DUP](#) <Zd>.<T>, #0

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

## Operation

The description of [DUP \(immediate\)](#) gives the operational pseudocode for this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FMOV (immediate, predicated)

Move 8-bit floating-point immediate to vector elements (predicated)

Move a floating-point immediate into each active element in the destination vector. Inactive elements in the destination vector register remain unmodified.

This is an alias of [FCPY](#). This means:

- The encodings in this description are named to match the encodings of [FCPY](#).
- The description of [FCPY](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size		0	1	Pg			1	1	0	imm8						Zd							

FMOV <Zd>.<T>, <Pg>/M, #<const>

is equivalent to

FCPY <Zd>.<T>, <Pg>/M, #<const>

and is always the preferred disassembly.

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.

<const> Is a floating-point immediate value expressable as  $\pm n \div 16 \times 2^r$ , where n and r are integers such that  $16 \leq n \leq 31$  and  $-3 \leq r \leq 4$ , i.e. a normalized binary floating-point encoding with 1 sign bit, 3-bit exponent, and 4-bit fractional part, encoded in the "imm8" field.

## Operation

The description of [FCPY](#) gives the operational pseudocode for this instruction.

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FMOV (immediate, unpredicated)

Move 8-bit floating-point immediate to vector elements (unpredicated)

Unconditionally broadcast the floating-point immediate into each element of the destination vector. This instruction is unpredicated.

This is an alias of [FDUP](#). This means:

- The encodings in this description are named to match the encodings of [FDUP](#).
- The description of [FDUP](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size			1	1	1	0	0	1	1	1	0	imm8								Zd			

FMOV <Zd>.<T>, #<const>

is equivalent to

[FDUP](#) <Zd>.<T>, #<const>

and is always the preferred disassembly.

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<const> Is a floating-point immediate value expressable as  $\pm n \div 16 \times 2^r$ , where n and r are integers such that  $16 \leq n \leq 31$  and  $-3 \leq r \leq 4$ , i.e. a normalized binary floating-point encoding with 1 sign bit, 3-bit exponent, and 4-bit fractional part, encoded in the "imm8" field.

## Operation

The description of [FDUP](#) gives the operational pseudocode for this instruction.

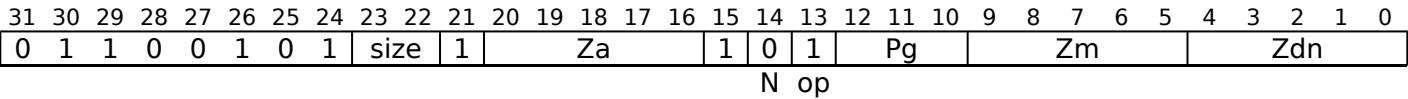
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FMSB

Floating-point fused multiply-subtract vectors (predicated), writing multiplicand [Zdn = Za + -Zdn \* Zm]

Multiply the corresponding active floating-point elements of the first and second source vectors and subtract from elements of the third (addend) vector without intermediate rounding. Destructively place the results in the destination and first source (multiplicand) vector. Inactive elements in the destination vector register remain unmodified.



FMSB <Zdn>.<T>, <Pg>/M, <Zm>.<T>, <Za>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
integer a = UInt(Za);
boolean op1_neg = TRUE;
boolean op3_neg = FALSE;
```

Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

<Za> Is the name of the third source scalable vector register, encoded in the "Za" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) operand3 = if AnyActiveElement(mask, esize) then Z[a] else Zeros();
bits(VL) result;

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    bits(esize) element3 = Elem[operand3, e, esize];

    if op1_neg then element1 = FPNeg(element1);
    if op3_neg then element3 = FPNeg(element3);
    Elem[result, e, esize] = FPMulAdd(element3, element1, element2, FPCR[]);
  else
    Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# FMUL (immediate)

Floating-point multiply by immediate (predicated)

Multiply by an immediate each active floating-point element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate may take the value +0.5 or +2.0 only. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	1	1	0	1	0	0	1	0	0	Pg	0	0	0	0	i1	Zdn						

FMUL <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <const>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
bits(esize) imm = if i1 == '0' then FPPointFive('0') else FPTwo('0');
```

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<const> Is the floating-point immediate value, encoded in "i1":

i1	<const>
0	#0.5
1	#2.0

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPMul(element1, imm, FPCR[]);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FMUL (vectors, predicated)

Floating-point multiply vectors (predicated)

Multiply active floating-point elements of the first source vector by corresponding floating-point elements of the second source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	0	1	0	1	0	0	Pg	Zm				Zdn								

FMUL <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element2 = Elem[operand2, e, esize];
        Elem[result, e, esize] = FPMul(element1, element2, FPCR[]);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FMUL (vectors, unpredicated)

Floating-point multiply vectors (unpredicated)

Multiply all elements of the first source vector by corresponding floating-point elements of the second source vector and place the results in the corresponding elements of the destination vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	1	1	0	0	1	0	1	size	0	Zm						0	0	0	0	1	0	Zn						Zd					

FMUL <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = FPMul(element1, element2, FPCR[]);

Z[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## FMUL (indexed)

Floating-point multiply by indexed elements

Multiply all floating-point elements within each 128-bit segment of the first source vector by the specified element in the corresponding second source vector segment. The results are placed in the corresponding elements of the destination vector.

The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 1 to 3 bits depending on the size of the element. This instruction is unpredicated.

It has encodings from 3 classes: [Half-precision](#) , [Single-precision](#) and [Double-precision](#)

### Half-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	0	i3h	1	i3l	Zm				0	0	1	0	0	0	Zn				Zd					

**FMUL** <Zd>.H, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

### Single-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	1	0	1	i2	Zm				0	0	1	0	0	0	Zn				Zd					
								size<1>		size<0>																					

**FMUL** <Zd>.S, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

### Double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	1	1	1	i1	Zm				0	0	1	0	0	0	Zn				Zd					
								size<1>		size<0>																					

**FMUL** <Zd>.D, <Zn>.D, <Zm>.D[<imm>]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer index = UInt(i1);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

### Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> For the half-precision and single-precision variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  
For the double-precision variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
- <imm> For the half-precision variant: is the immediate index, in the range 0 to 7, encoded in the "i3h:i3l" fields.  
For the single-precision variant: is the immediate index, in the range 0 to 3, encoded in the "i2" field.  
For the double-precision variant: is the immediate index, in the range 0 to 1, encoded in the "i1" field.

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
integer eltspersegment = 128 DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltspersegment);
    integer s = segmentbase + index;
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, s, esize];
    Elem[result, e, esize] = FPMul(element1, element2, FPCR[]);

Z[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FMULX

Floating-point multiply-extended vectors (predicated)

Multiply active floating-point elements of the first source vector by corresponding floating-point elements of the second source vector except that  $\infty \times 0.0$  gives 2.0 instead of NaN, and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

The instruction can be used with FRECPX to safely convert arbitrary elements in mathematical vector space to UNIT VECTORS or DIRECTION VECTORS with length 1.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	1	0	1	0	1	0	0	Pg	Zm				Zdn								

FMULX <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element2 = Elem[operand2, e, esize];
        Elem[result, e, esize] = FPMuLX(element1, element2, FPCR[]);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:



- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FNEG

Floating-point negate (predicated)

Negate each active floating-point element of the source vector, and place the results in the corresponding elements of the destination vector. This inverts the sign bit and cannot signal a floating-point exception. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	1	0	1	1	0	1	Pg				Zn				Zd					

FNEG <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) result = Z[d];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element = Elem[operand, e, esize];
        Elem[result, e, esize] = FPNeg(element);

Z[d] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

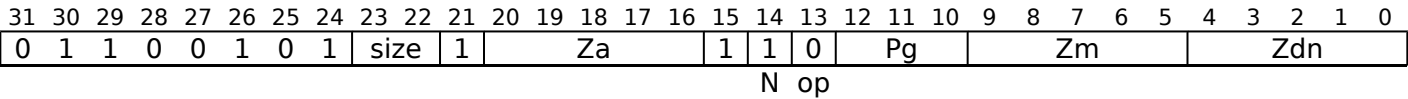
- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



FNMAD

Floating-point negated fused multiply-add vectors (predicated), writing multiplicand [ $Z_{dn} = -Z_a + -Z_{dn} * Z_m$ ]

Multiply the corresponding active floating-point elements of the first and second source vectors and add to elements of the third (addend) vector without intermediate rounding. Destructively place the negated results in the destination and first source (multiplicand) vector. Inactive elements in the destination vector register remain unmodified.



FNMAD <Zdn>.<T>, <Pg>/M, <Zm>.<T>, <Za>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
integer a = UInt(Za);
boolean op1_neg = TRUE;
boolean op3_neg = TRUE;
```

Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

<Za> Is the name of the third source scalable vector register, encoded in the "Za" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) operand3 = if AnyActiveElement(mask, esize) then Z[a] else Zeros();
bits(VL) result;

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    bits(esize) element3 = Elem[operand3, e, esize];

    if op1_neg then element1 = FPNeg(element1);
    if op3_neg then element3 = FPNeg(element3);
    Elem[result, e, esize] = FPMulAdd(element3, element1, element2, FPCR[]);
  else
    Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

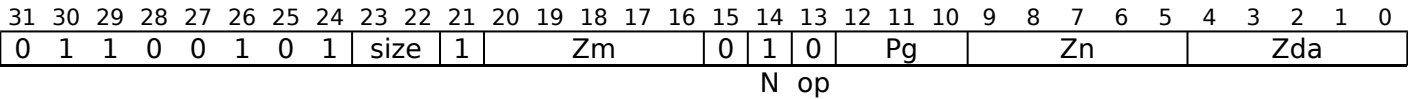
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FNMLA

Floating-point negated fused multiply-add vectors (predicated), writing addend [Zda = -Zda + -Zn \* Zm]

Multiply the corresponding active floating-point elements of the first and second source vectors and add to elements of the third source (addend) vector without intermediate rounding. Destructively place the negated results in the destination and third source (addend) vector. Inactive elements in the destination vector register remain unmodified.



FNMLA <Zda>.<T>, <Pg>/M, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean op1_neg = TRUE;
boolean op3_neg = TRUE;
```

Assembler Symbols

<Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    bits(esize) element3 = Elem[operand3, e, esize];

    if op1_neg then element1 = FPNeg(element1);
    if op3_neg then element3 = FPNeg(element3);
    Elem[result, e, esize] = FPMulAdd(element3, element1, element2, FPCR[]);
  else
    Elem[result, e, esize] = Elem[operand3, e, esize];

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

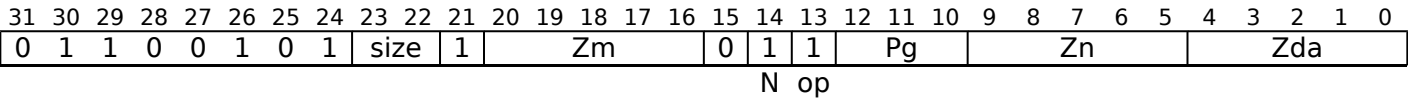
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FNMLS

Floating-point negated fused multiply-subtract vectors (predicated), writing addend [ $Zda = -Zda + Zn * Zm$ ]

Multiply the corresponding active floating-point elements of the first and second source vectors and subtract from elements of the third source (addend) vector without intermediate rounding. Destructively place the negated results in the destination and third source (addend) vector. Inactive elements in the destination vector register remain unmodified.



FNMLS <Zda>.<T>, <Pg>/M, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean op1_neg = FALSE;
boolean op3_neg = TRUE;
```

Assembler Symbols

<Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element1 = Elem[operand1, e, esize];
        bits(esize) element2 = Elem[operand2, e, esize];
        bits(esize) element3 = Elem[operand3, e, esize];

        if op1_neg then element1 = FPNeg(element1);
        if op3_neg then element3 = FPNeg(element3);
        Elem[result, e, esize] = FPMu1Add(element3, element1, element2, FPCR[]);
    else
        Elem[result, e, esize] = Elem[operand3, e, esize];

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

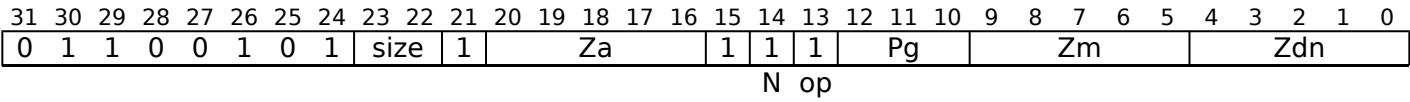
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FNMSB

Floating-point negated fused multiply-subtract vectors (predicated), writing multiplicand [ $Z_{dn} = -Z_a + Z_{dn} * Z_m$ ]

Multiply the corresponding active floating-point elements of the first and second source vectors and subtract from elements of the third (addend) vector without intermediate rounding. Destructively place the negated results in the destination and first source (multiplicand) vector. Inactive elements in the destination vector register remain unmodified.



FNMSB <Zdn>.<T>, <Pg>/M, <Zm>.<T>, <Za>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
integer a = UInt(Za);
boolean op1_neg = FALSE;
boolean op3_neg = TRUE;
```

Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

<Za> Is the name of the third source scalable vector register, encoded in the "Za" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) operand3 = if AnyActiveElement(mask, esize) then Z[a] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element1 = Elem[operand1, e, esize];
        bits(esize) element2 = Elem[operand2, e, esize];
        bits(esize) element3 = Elem[operand3, e, esize];

        if op1_neg then element1 = FPNeg(element1);
        if op3_neg then element3 = FPNeg(element3);
        Elem[result, e, esize] = FPMu1Add(element3, element1, element2, FPCR[]);
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FRECPE

Floating-point reciprocal estimate (unpredicated)

Find the approximate reciprocal of each floating-point element of the source vector, and place the results in the corresponding elements of the destination vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size		0	0	1	1	1	0	0	0	1	1	0	0	Zn				Zd					

FRECPE <Zd>.<T>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand = Z[n];
bits(VL) result;

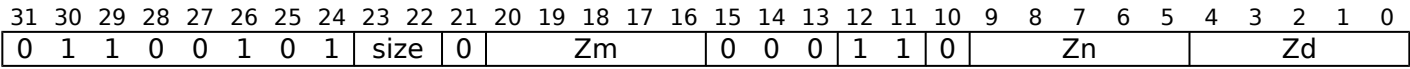
for e = 0 to elements-1
    bits(esize) element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPRecipEstimate(element, FPCR[]);

Z[d] = result;
```

FRECPS

Floating-point reciprocal step (unpredicated)

Multiply corresponding floating-point elements of the first and second source vectors, subtract the products from 2.0 without intermediate rounding and place the results in the corresponding elements of the destination vector. This instruction is unpredicated.  
This instruction can be used to perform a single Newton-Raphson iteration for calculating the reciprocal of a vector of floating-point values.



FRECPS <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = FPRecipStepFused(element1, element2);

Z[d] = result;
```

# FRECPX

Floating-point reciprocal exponent (predicated)

Invert the exponent and zero the fractional part of each active floating-point element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

The result of this instruction can be used with FMULX to convert arbitrary elements in mathematical vector space to "unit vectors" or "direction vectors" of length 1.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	1	1	0	0	1	0	1	Pg			Zn				Zd						

FRECPX <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) result = Z[d];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element = Elem[operand, e, esize];
        Elem[result, e, esize] = FPRecpX(element, FPCR[]);

Z[d] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



# FRINT<r>

Floating-point round to integral value (predicated)

Round to an integral floating-point value with the specified rounding option from each active floating-point element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

The <r> symbol specifies one of the following rounding options: N (to nearest, with ties to even), A (to nearest, with ties away from zero), M (toward minus Infinity), P (toward plus Infinity), Z (toward zero), I (current FPCR rounding mode), or X (current FPCR rounding mode, signalling inexact).

It has encodings from 7 classes: [Current mode](#) , [Current mode signalling inexact](#) , [Nearest with ties to away](#) , [Nearest with ties to even](#) , [Toward zero](#) , [Toward minus infinity](#) and [Toward plus infinity](#)

## Current mode

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	1	1	1	1	0	1	Pg						Zn					Zd		

FRINTI <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean exact = FALSE;
FPRounding rounding = FPRoundingMode(FPCR[]);
```

## Current mode signalling inexact

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	1	1	0	1	0	1	Pg							Zn				Zd		

FRINTX <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean exact = TRUE;
FPRounding rounding = FPRoundingMode(FPCR[]);
```

## Nearest with ties to away

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	1	0	0	1	0	1	Pg							Zn				Zd		

FRINTA <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean exact = FALSE;
FPRounding rounding = FPRounding_TIEAWAY;
```



Nearest with ties to even

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	0	0	0	1	0	1	Pg													

```
FRINTN <Zd>.<T>, <Pg>/M, <Zn>.<T>
```

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean exact = FALSE;
FPRounding rounding = FPRounding_TIEEVEN;
```

Toward zero

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	0	1	1	1	0	1	Pg													

```
FRINTZ <Zd>.<T>, <Pg>/M, <Zn>.<T>
```

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean exact = FALSE;
FPRounding rounding = FPRounding_ZERO;
```

Toward minus infinity

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	0	1	0	1	0	1	Pg													

```
FRINTM <Zd>.<T>, <Pg>/M, <Zn>.<T>
```

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean exact = FALSE;
FPRounding rounding = FPRounding_NEGINF;
```

Toward plus infinity

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	0	0	1	1	0	1	Pg													

```
FRINTP <Zd>.<T>, <Pg>/M, <Zn>.<T>
```

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean exact = FALSE;
FPRounding rounding = FPRounding_POSINF;
```

Assembler Symbols

- <Zd>

Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T>

Is the size specifier, encoded in "size":
- | size | <T>      |
|------|----------|
| 00   | RESERVED |
| 01   | H        |
| 10   | S        |
| 11   | D        |
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn>

Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) result = Z[d];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element = Elem[operand, e, esize];
        Elem[result, e, esize] = FPRoundInt(element, FPCR[], rounding, exact);

Z[d] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

FRSQRTE

Floating-point reciprocal square root estimate (unpredicated)

Find the approximate reciprocal square root of each active floating-point element of the source vector, and place the results in the corresponding elements of the destination vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size		0	0	1	1	1	1	0	0	1	1	0	0	Zn				Zd					

FRSQRTE <Zd>.<T>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand = Z[n];
bits(VL) result;

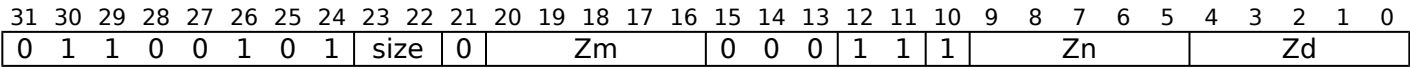
for e = 0 to elements-1
    bits(esize) element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPRSqrtEstimate(element, FPCR[]);

Z[d] = result;
```

FRSQRTS

Floating-point reciprocal square root step (unpredicated)

Multiply corresponding floating-point elements of the first and second source vectors, subtract the products from 3.0 and divide the results by 2.0 without any intermediate rounding and place the results in the corresponding elements of the destination vector. This instruction is unpredicated.  
This instruction can be used to perform a single Newton-Raphson iteration for calculating the reciprocal square root of a vector of floating-point values.



FRSQRTS <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = FPRSqrtStepFused(element1, element2);

Z[d] = result;
```

# FSCALE

Floating-point adjust exponent by vector (predicated)

Multiply the active floating-point elements of the first source vector by 2.0 to the power of the signed integer values in the corresponding elements of the second source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	1	0	0	1	1	0	0	Pg				Zm				Zdn					

FSCALE <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        integer element2 = SInt(Elem[operand2, e, esize]);
        Elem[result, e, esize] = FPScale(element1, element2, FPCR[]);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FSQRT

Floating-point square root (predicated)

Calculate the square root of each active floating-point element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	1	1	0	1	1	0	1	Pg	Zn				Zd								

FSQRT <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) result = Z[d];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element = Elem[operand, e, esize];
        Elem[result, e, esize] = FPSqrt(element, FPCR[]);

Z[d] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.





# FSUB (immediate)

Floating-point subtract immediate (predicated)

Subtract an immediate from each active floating-point element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate may take the value +0.5 or +1.0 only. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	1	1	0	0	1	1	0	0	Pg	0	0	0	0	i1	Zdn							

FSUB <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <const>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
bits(esize) imm = if i1 == '0' then FPPointFive('0') else FPOne('0');
```

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<const> Is the floating-point immediate value, encoded in "i1":

i1	<const>
0	#0.5
1	#1.0

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPSub(element1, imm, FPCR[]);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FSUB (vectors, predicated)

Floating-point subtract vectors (predicated)

Subtract active floating-point elements of the second source vector from corresponding floating-point elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	0	0	1	1	0	0	Pg	Zm				Zdn								

FSUB <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element2 = Elem[operand2, e, esize];
        Elem[result, e, esize] = FSub(element1, element2, FPCR[]);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FSUB (vectors, unpredicated)

Floating-point subtract vectors (unpredicated)

Subtract all floating-point elements of the second source vector from corresponding elements of the first source vector and place the results in the corresponding elements of the destination vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size		0	Zm				0	0	0	0	0	1	Zn				Zd						

FSUB <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = FPSub(element1, element2, FPCR[]);

Z[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FSUBR (immediate)

Floating-point reversed subtract from immediate (predicated)

Reversed subtract from an immediate each active floating-point element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate may take the value +0.5 or +1.0 only. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	1	1	0	1	1	1	0	0	Pg	0	0	0	0	i1	Zdn							

FSUBR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <const>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
bits(esize) imm = if i1 == '0' then FPPointFive('0') else FPOne('0');
```

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<const> Is the floating-point immediate value, encoded in "i1":

i1	<const>
0	#0.5
1	#1.0

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPSub(imm, element1, FPCR[]);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FSUBR (vectors)

Floating-point reversed subtract vectors (predicated)

Reversed subtract active floating-point elements of the first source vector from corresponding floating-point elements of the second source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	0	1	1	1	0	0	Pg	Zm				Zdn								

FSUBR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element2 = Elem[operand2, e, esize];
        Elem[result, e, esize] = FPSub(element2, element1, FPCR[]);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.



- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# FTMAD

Floating-point trigonometric multiply-add coefficient

The FTMAD instruction calculates the series terms for either SIN(x) or COS(x), where the argument x has been adjusted to be in the range  $-\pi/4 < x \leq \pi/4$ .

To calculate the series terms of SIN(x) and COS(x) the initial source operands of FTMAD should be zero in the first source vector and  $x^2$  in the second source vector. The FTMAD instruction is then executed eight times to calculate the sum of eight series terms, which gives a result of sufficient precision.

The FTMAD instruction multiplies each element of the first source vector by the absolute value of the corresponding element of the second source vector and performs a fused addition of each product with a value obtained from a table of hard-wired coefficients, and places the results destructively in the first source vector.

The coefficients are different for SIN(x) and COS(x), and are selected by a combination of the sign bit in the second source element and an immediate index in the range 0 to 7.

This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size		0	1	0	imm3		1	0	0	0	0	0	Zm				Zdn						

FTMAD <Zdn>.<T>, <Zdn>.<T>, <Zm>.<T>, #<imm>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
integer imm = UInt(imm3);
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

<imm> Is the unsigned immediate operand, in the range 0 to 7, encoded in the "imm3" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = FPTrigMAdd(imm, element1, element2, FPCR[]);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

FTSMUL

Floating-point trigonometric starting value

The FTSMUL instruction calculates the initial value for the FTMAD instruction. The instruction squares each element in the first source vector and then sets the sign bit to a copy of bit 0 of the corresponding element in the second source register, and places the results in the destination vector. This instruction is unpredicated. To compute SIN(x) or COS(x) the instruction is executed with elements of the first source vector set to x, adjusted to be in the range  $-\pi/4 < x \leq \pi/4$ . The elements of the second source vector hold the corresponding value of the quadrant Q number as an integer not a floating-point value. The value Q satisfies the relationship  $(2q-1) \times \pi/4 < x \leq (2q+1) \times \pi/4$ .

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	Zm						0	0	0	0	1	1	Zn						Zd			

FTSMUL <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = FPTrigSMul(element1, element2, FPCR[]);

Z[d] = result;
```

FTSSEL

Floating-point trigonometric select coefficient

The FTSSEL instruction selects the coefficient for the final multiplication in the polynomial series approximation. The instruction places the value 1.0 or a copy of the first source vector element in the destination element, depending on bit 0 of the quadrant number Q held in the corresponding element of the second source vector. The sign bit of the destination element is copied from bit 1 of the corresponding value of Q. This instruction is unpredicated. To compute SIN(x) or COS(x) the instruction is executed with elements of the first source vector set to x, adjusted to be in the range  $-\pi/4 < x \leq \pi/4$ . The elements of the second source vector hold the corresponding value of the quadrant Q number as an integer not a floating-point value. The value Q satisfies the relationship  $(2q-1) \times \pi/4 < x \leq (2q+1) \times \pi/4$ .

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	0	0	0	0	1	0	0	size	1	Zm						1	0	1	1	0	0	Zn						Zd				

FTSSEL <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = FPTrigSSel(element1, element2);

Z[d] = result;
```

# INCB, INCD, INCH, INCW (scalar)

Increment scalar by multiple of predicate constraint element count

Determines the number of active elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment the scalar destination.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 4 classes: [Byte](#) , [Doubleword](#) , [Halfword](#) and [Word](#)

## Byte

31	30	29	28	27	26	25	24	23		22		21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	1	1	imm4				1	1	1	0	0	0	pattern					Rdn						
size<1>size<0>																D																	

INCB <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

## Doubleword

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	1	1	1	imm4				1	1	1	0	0	0	pattern					Rdn				
size<1>size<0>																D															

INCD <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

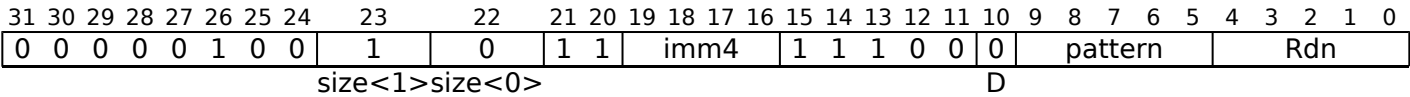
## Halfword

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1	imm4				1	1	1	0	0	0	pattern					Rdn					
size<1>size<0>																D															

INCH <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

Word



```
INCW <Xdn>{, <pattern>{, MUL #<imm>}}
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

Assembler Symbols

- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

Operation

```
CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(64) operand1 = X[dn];
X[dn] = operand1 + (count * imm);
```

## INCD, INCH, INCW (vector)

Increment vector by multiple of predicate constraint element count

Determines the number of active elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment all destination vector elements.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 3 classes: [Doubleword](#) , [Halfword](#) and [Word](#)

### Doubleword

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	1	1	1	imm4				1	1	0	0	0	0	0	pattern					Zdn			
size<1>size<0>																D															

**INCD** <Zdn>.D{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

### Halfword

31	30	29	28	27	26	25	24	23		22		21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1		1 1		imm4			1 1 0 0 0			0			pattern					Zdn					
size<1>size<0>																D																	

**INCH** <Zdn>.H{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

### Word

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	0	1	1	imm4				1	1	0	0	0	0	0	pattern				Zdn				
size<1>size<0>																D															

**INCW** <Zdn>.S{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```



Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	P0W2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer count = DecodePredCount(pat, esize);
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    Elem[result, e, esize] = Elem[operand1, e, esize] + (count * imm);

Z[dn] = result;
```

Operational information

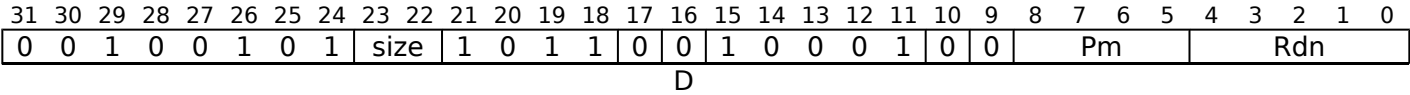
This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

# INCP (scalar)

Increment scalar by count of true predicate elements

Counts the number of true elements in the source predicate and then uses the result to increment the scalar destination.



INCP <Xdn>, <Pm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Rdn);
```

## Assembler Symbols

- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Pm> Is the name of the source scalable predicate register, encoded in the "Pm" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) operand1 = X[dn];
bits(PL) operand2 = P[m];
integer count = 0;

for e = 0 to elements-1
    if ElemP[operand2, e, esize] == '1' then
        count = count + 1;

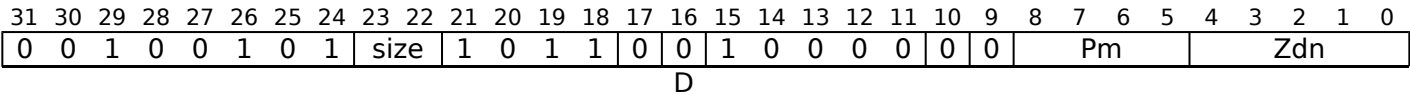
X[dn] = operand1 + count;
```

# INCP (vector)

Increment vector by count of true predicate elements

Counts the number of true elements in the source predicate and then uses the result to increment all destination vector elements.

The predicate size specifier may be omitted in assembler source code, but this is deprecated and will be prohibited in a future release of the architecture.



INCP <Zdn>.<T>, <Pm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Zdn);
```

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pm> Is the name of the source scalable predicate register, encoded in the "Pm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(PL) operand2 = P[m];
bits(VL) result;
integer count = 0;

for e = 0 to elements-1
    if ElemP[operand2, e, esize] == '1' then
        count = count + 1;

for e = 0 to elements-1
    Elem[result, e, esize] = Elem[operand1, e, esize] + count;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



# INDEX (immediates)

Create index starting from and incremented by immediate

Populates the destination vector by setting the first element to the first signed immediate integer operand and monotonically incrementing the value by the second signed immediate integer operand for each subsequent element. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1	imm5b						0	1	0	0	0	0	imm5					Zd				

INDEX <Zd>.<T>, #<imm1>, #<imm2>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer d = UInt(Zd);
integer imm1 = SInt(imm5);
integer imm2 = SInt(imm5b);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<imm1> Is the first signed immediate operand, in the range -16 to 15, encoded in the "imm5" field.

<imm2> Is the second signed immediate operand, in the range -16 to 15, encoded in the "imm5b" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) result;

for e = 0 to elements-1
    integer index = imm1 + e * imm2;
    Elem[result, e, esize] = index<esize-1:0>;

Z[d] = result;
```

INDEX (immediate, scalar)

Create index starting from immediate and incremented by general-purpose register

Populates the destination vector by setting the first element to the first signed immediate integer operand and monotonically incrementing the value by the second signed scalar integer operand for each subsequent element. The scalar source operand is a general-purpose register in which only the least significant bits corresponding to the vector element size are used and any remaining bits are ignored. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1	Rm						0	1	0	0	1	0	imm5					Zd				

INDEX <Zd>.<T>, #<imm>, <R><m>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Rm);
integer d = UInt(Zd);
integer imm = SInt(imm5);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<imm> Is the signed immediate operand, in the range -16 to 15, encoded in the "imm5" field.

<R> Is a width specifier, encoded in "size":

size	<R>
01	W
x0	W
11	X

<m> Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(esize) operand2 = X[m];
integer element2 = SInt(operand2);
bits(VL) result;

for e = 0 to elements-1
    integer index = imm + e * element2;
    Elem[result, e, esize] = index<esize-1:0>;

Z[d] = result;
```

# INDEX (scalar, immediate)

Create index starting from general-purpose register and incremented by immediate

Populates the destination vector by setting the first element to the first signed scalar integer operand and monotonically incrementing the value by the second signed immediate integer operand for each subsequent element. The scalar source operand is a general-purpose register in which only the least significant bits corresponding to the vector element size are used and any remaining bits are ignored. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1						imm5		0	1	0	0	0	1									Zd

INDEX <Zd>.<T>, <R><n>, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Rn);
integer d = UInt(Zd);
integer imm = SInt(imm5);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<R> Is a width specifier, encoded in "size":

size	<R>
01	W
x0	W
11	X

<n> Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rn" field.

<imm> Is the signed immediate operand, in the range -16 to 15, encoded in the "imm5" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(esize) operand1 = X[n];
integer element1 = SInt(operand1);
bits(VL) result;

for e = 0 to elements-1
    integer index = element1 + e * imm;
    Elem[result, e, esize] = index<esize-1:0>;

Z[d] = result;
```

# INDEX (scalars)

Create index starting from and incremented by general-purpose register

Populates the destination vector by setting the first element to the first signed scalar integer operand and monotonically incrementing the value by the second signed scalar integer operand for each subsequent element. The scalar source operands are general-purpose registers in which only the least significant bits corresponding to the vector element size are used and any remaining bits are ignored. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	0	0	0	0	1	0	0	size	1	Rm						0	1	0	0	1	1	Rn						Zd					

INDEX <Zd>.<T>, <R><n>, <R><m>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<R> Is a width specifier, encoded in "size":

size	<R>
01	W
x0	W
11	X

<n> Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rn" field.

<m> Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(esize) operand1 = X[n];
integer element1 = SInt(operand1);
bits(esize) operand2 = X[m];
integer element2 = SInt(operand2);
bits(VL) result;

for e = 0 to elements-1
    integer index = element1 + e * element2;
    Elem[result, e, esize] = index<esize-1:0>;

Z[d] = result;
```





# INSR (scalar)

Insert general-purpose register in shifted vector

Shift the destination vector left by one element, and then place a copy of the least-significant bits of the general-purpose register in element 0 of the destination vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size		1	0	0	1	0	0	0	0	1	1	1	0	Rm				Zdn					

INSR <Zdn>.<T>, <R><m>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer dn = UInt(Zdn);
integer m = UInt(Rm);
```

## Assembler Symbols

- <Zdn>

Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <R>

Is a width specifier, encoded in "size":

size	<R>
01	W
x0	W
11	X
- <m>

Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
bits(VL) dest = Z[dn];
bits(esize) src = X[m];
Z[dn] = dest<VL-esize-1:0> : src;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

INSR (SIMD&FP scalar)

Insert SIMD&FP scalar register in shifted vector

Shift the destination vector left by one element, and then place a copy of the SIMD&FP scalar register in element 0 of the destination vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size		1	1	0	1	0	0	0	0	1	1	1	0	Vm				Zdn					

INSR <Zdn>.<T>, <V><m>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer dn = UInt(Zdn);
integer m = UInt(Vm);
```

Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<V> Is a width specifier, encoded in "size":

size	<V>
00	B
01	H
10	S
11	D

<m> Is the number [0-31] of the source SIMD&FP register, encoded in the "Vm" field.

Operation

```
CheckSVEEnabled();
bits(VL) dest = Z[dn];
bits(esize) src = V[m];
Z[dn] = dest<VL-esize-1:0> : src;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

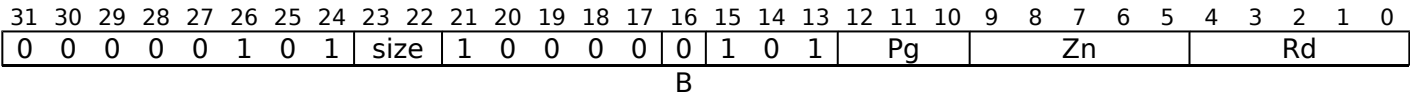
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LASTA (scalar)

Extract element after last to general-purpose register

If there is an active element then extract the element after the last active element modulo the number of elements from the final source vector register. If there are no active elements, extract element zero. Then zero-extend and place the extracted element in the destination general-purpose register.



LASTA <R><d>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer rsize = if esize < 64 then 32 else 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Rd);
boolean isBefore = FALSE;
```

## Assembler Symbols

<R> Is a width specifier, encoded in “size”:

size	<R>
01	W
x0	W
11	X

<d> Is the number [0-30] of the destination general-purpose register or the name ZR (31), encoded in the “Rd” field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the “Pg” field.

<Zn> Is the name of the source scalable vector register, encoded in the “Zn” field.

<T> Is the size specifier, encoded in “size”:

size	<T>
00	B
01	H
10	S
11	D

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(rsize) result;
integer last = LastActiveElement(mask, esize);

if isBefore then
    if last < 0 then last = elements - 1;
else
    last = last + 1;
    if last >= elements then last = 0;
result = ZeroExtend(Elem[operand, last, esize]);

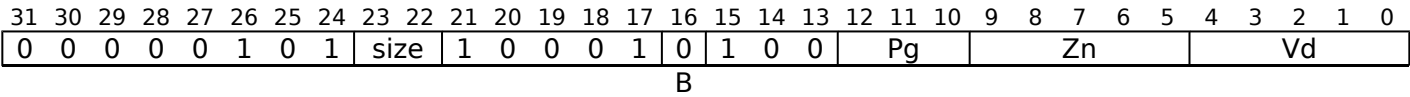
X[d] = result;
```



LASTA (SIMD&FP scalar)

Extract element after last to SIMD&FP scalar register

If there is an active element then extract the element after the last active element modulo the number of elements from the final source vector register. If there are no active elements, extract element zero. Then place the extracted element in the destination SIMD&FP scalar register.



LASTA <V><d>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
boolean isBefore = FALSE;
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D

<d> Is the number [0-31] of the destination SIMD&FP register, encoded in the "Vd" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<T> Is the size specifier, encoded in “size”:

size	<T>
00	B
01	H
10	S
11	D

Operation

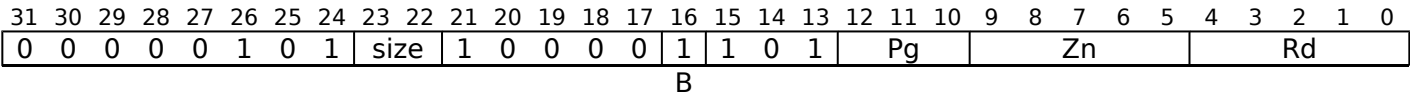
```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
integer last = LastActiveElement(mask, esize);

if isBefore then
    if last < 0 then last = elements - 1;
else
    last = last + 1;
    if last >= elements then last = 0;
V[d] = Elem[operand, last, esize];
```

# LASTB (scalar)

Extract last element to general-purpose register

If there is an active element then extract the last active element from the final source vector register. If there are no active elements, extract the highest-numbered element. Then zero-extend and place the extracted element in the destination general-purpose register.



LASTB <R><d>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer rsize = if esize < 64 then 32 else 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Rd);
boolean isBefore = TRUE;
```

## Assembler Symbols

<R> Is a width specifier, encoded in “size”:

size	<R>
01	W
x0	W
11	X

<d> Is the number [0-30] of the destination general-purpose register or the name ZR (31), encoded in the "Rd" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<T> Is the size specifier, encoded in “size”:

size	<T>
00	B
01	H
10	S
11	D

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(rsize) result;
integer last = LastActiveElement(mask, esize);

if isBefore then
    if last < 0 then last = elements - 1;
else
    last = last + 1;
    if last >= elements then last = 0;
result = ZeroExtend(Elem[operand, last, esize]);

X[d] = result;
```

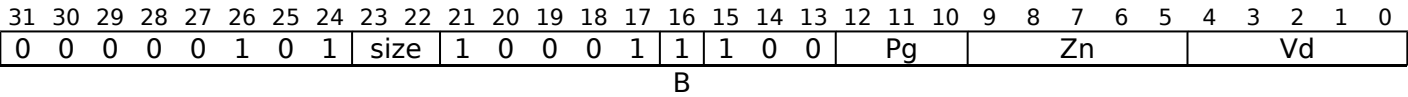




# LASTB (SIMD&FP scalar)

Extract last element to SIMD&FP scalar register

If there is an active element then extract the last active element from the final source vector register. If there are no active elements, extract the highest-numbered element. Then place the extracted element in the destination SIMD&FP register.



LASTB <V><d>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
boolean isBefore = TRUE;
```

## Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D

<d> Is the number [0-31] of the destination SIMD&FP register, encoded in the "Vd" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<T> Is the size specifier, encoded in “size”:

size	<T>
00	B
01	H
10	S
11	D

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
integer last = LastActiveElement(mask, esize);

if isBefore then
    if last < 0 then last = elements - 1;
else
    last = last + 1;
    if last >= elements then last = 0;
V[d] = Elem[operand, last, esize];
```

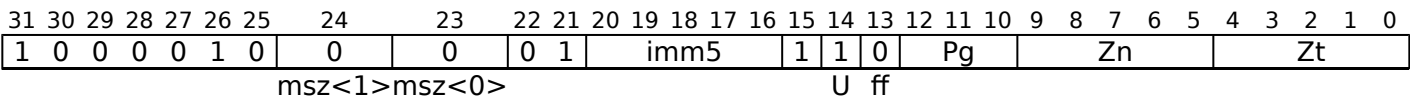
# LD1B (vector plus immediate)

Gather load unsigned bytes to vector (immediate index)

Gather load of unsigned bytes to active elements of a vector register from memory addresses generated by a vector base plus immediate index. The index is in the range 0 to 31. Inactive elements will not cause a read from Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

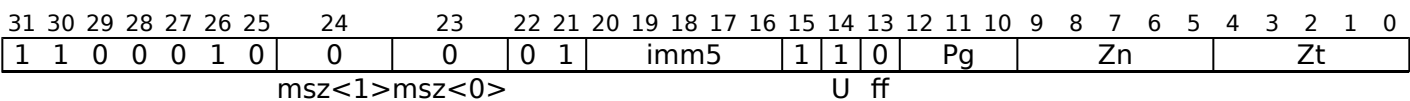
## 32-bit element



LD1B { <Zt>.S }, <Pg>/Z, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = UInt(imm5);
```

## 64-bit element



LD1B { <Zt>.D }, <Pg>/Z, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = UInt(imm5);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, in the range 0 to 31, defaulting to 0, encoded in the "imm5" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) base;
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if AnyActiveElement(mask, esize) then
    base = Z[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LD1B (scalar plus immediate)

Contiguous load unsigned bytes to vector (immediate index)

Contiguous load of unsigned bytes to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 4 classes: [8-bit element](#) , [16-bit element](#) , [32-bit element](#) and [64-bit element](#)

### 8-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	0	0	0	0	imm4			1	0	1	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

LD1B { <Zt>.B }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

### 16-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	0	0	1	0	imm4			1			0	1	Pg			Rn				Zt				
dtype<3:1>dtype<0>																															

LD1B { <Zt>.H }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

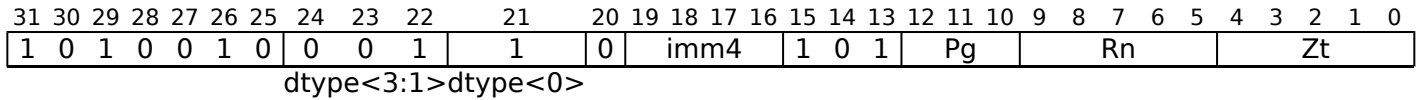
### 32-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	0	1	0	0	imm4			1	0	1	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

LD1B { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

## 64-bit element



**LD1B { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]**

```

if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = SInt(imm4);

```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + eoff * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LD1B (scalar plus scalar)

Contiguous load unsigned bytes to vector (scalar index)

Contiguous load of unsigned bytes to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 4 classes: [8-bit element](#) , [16-bit element](#) , [32-bit element](#) and [64-bit element](#)

### 8-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	0	0	0	Rm				0	1	0	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

LD1B { <Zt>.B }, <Pg>/Z, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 8;
integer msize = 8;
boolean unsigned = TRUE;
```

### 16-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	0	0	1	Rm				0	1	0	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

LD1B { <Zt>.H }, <Pg>/Z, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
integer msize = 8;
boolean unsigned = TRUE;
```

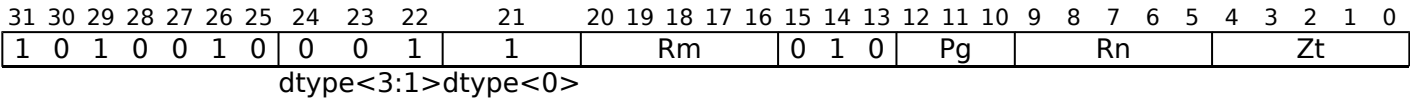
### 32-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	0	1	0	Rm				0	1	0	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

LD1B { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
boolean unsigned = TRUE;
```

64-bit element



LD1B { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
boolean unsigned = TRUE;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
bits(64) offset;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = base + (UInt(offset) + e) * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



## LD1B (scalar plus vector)

Gather load unsigned bytes to vector (vector index)

Gather load of unsigned bytes to active elements of a vector register from memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally sign or zero-extended from 32 to 64 bits. Inactive elements will not cause a read from Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 3 classes: [32-bit unpacked unscaled offset](#) , [32-bit unscaled offset](#) and [64-bit unscaled offset](#)

### 32-bit unpacked unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	xs	0	Zm				0	1	0	Pg				Rn				Zt					
msz<1>msz<0>										U ff																					

**LD1B** { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

### 32-bit unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	0	xs	0	Zm				0	1	0	Pg				Rn				Zt					
										U										ff											

**LD1B** { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

### 64-bit unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	1	0	Zm				1	1	0	Pg				Rn				Zt					
msz<1>msz<0>										U ff																					

LD1B { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
integer offs_size = 64;
boolean unsigned = TRUE;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) offset;
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = Z[m];

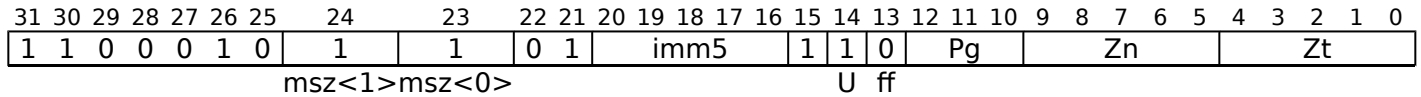
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        bits(64) addr = base + (off << scale);
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

## LD1D (vector plus immediate)

Gather load doublewords to vector (immediate index)

Gather load of doublewords to active elements of a vector register from memory addresses generated by a vector base plus immediate index. The index is a multiple of 8 in the range 0 to 248. Inactive elements will not cause a read from Device memory or signal faults, and are set to zero in the destination vector.



**LD1D { <Zt>.D }, <Pg>/Z, [<Zn>.D{, #<imm>}]**

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
boolean unsigned = TRUE;
integer offset = UInt(imm5);
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 8 in the range 0 to 248, defaulting to 0, encoded in the "imm5" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) base;
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if AnyActiveElement(mask, esize) then
    base = Z[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

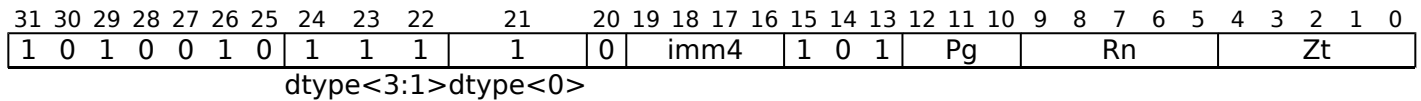
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LD1D (scalar plus immediate)

Contiguous load doublewords to vector (immediate index)

Contiguous load of doublewords to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.



**LD1D { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]**

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + eoff * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

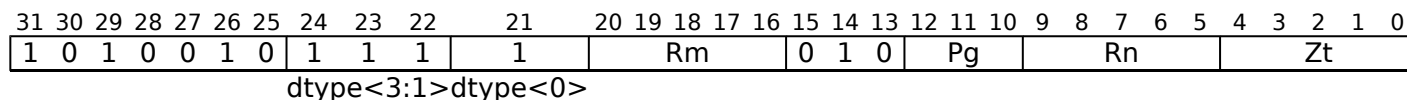
Z[t] = result;
```



## LD1D (scalar plus scalar)

Contiguous load doublewords to vector (scalar index)

Contiguous load of doublewords to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 8 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.



**LD1D { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #3]**

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
boolean unsigned = TRUE;
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
bits(64) offset;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = base + (UInt(offset) + e) * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```



## LD1D (scalar plus vector)

Gather load doublewords to vector (vector index)

Gather load of doublewords to active elements of a vector register from memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then optionally multiplied by 8. Inactive elements will not cause a read from Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 4 classes: [32-bit unpacked scaled offset](#) , [32-bit unpacked unscaled offset](#) , [64-bit scaled offset](#) and [64-bit unscaled offset](#)

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	1	1	xs	1	Zm					0	1	0	Pg			Rn				Zt					
																U		ff													

LD1D { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod> #3]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 3;
```

### 32-bit unpacked unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0								
1	1	0	0	0	1	0	1	1	xs	0	Zm					0	1	0	Pg			Rn				Zt													
msz<1>msz<0>																U												ff											

LD1D { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

### 64-bit scaled offset

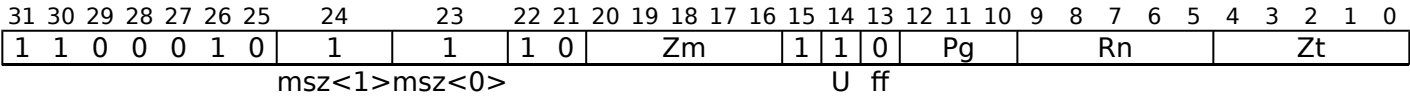
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	1	1	1	1	Zm					1	1	0	Pg			Rn				Zt					
																U		ff													



LD1D { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, LSL #3]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
integer offs_size = 64;
boolean unsigned = TRUE;
boolean offs_unsigned = TRUE;
integer scale = 3;
```

64-bit unscaled offset



LD1D { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
integer offs_size = 64;
boolean unsigned = TRUE;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) offset;
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = Z[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        bits(64) addr = base + (off << scale);
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

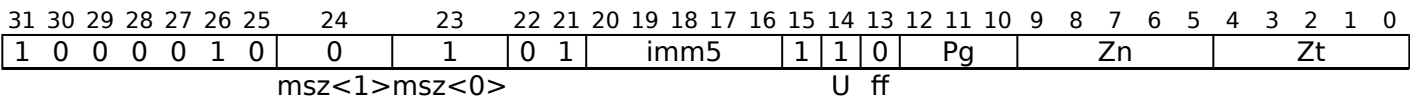
# LD1H (vector plus immediate)

Gather load unsigned halfwords to vector (immediate index)

Gather load of unsigned halfwords to active elements of a vector register from memory addresses generated by a vector base plus immediate index. The index is a multiple of 2 in the range 0 to 62. Inactive elements will not cause a read from Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

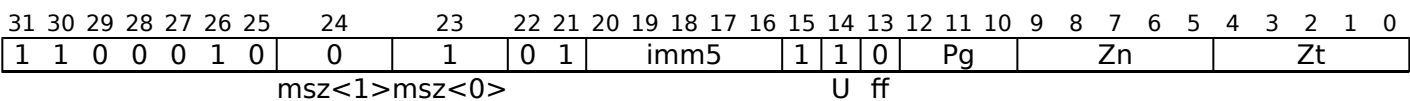
## 32-bit element



LD1H { <Zt>.S }, <Pg>/Z, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
boolean unsigned = TRUE;
integer offset = UInt(imm5);
```

## 64-bit element



LD1H { <Zt>.D }, <Pg>/Z, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
boolean unsigned = TRUE;
integer offset = UInt(imm5);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 2 in the range 0 to 62, defaulting to 0, encoded in the "imm5" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) base;
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if AnyActiveElement(mask, esize) then
    base = Z[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LD1H (scalar plus immediate)

Contiguous load unsigned halfwords to vector (immediate index)

Contiguous load of unsigned halfwords to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 3 classes: [16-bit element](#) , [32-bit element](#) and [64-bit element](#)

### 16-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	1	0	1	0		imm4	1	0	1		Pg						Rn					Zt		
dtype<3:1>dtype<0>																															

LD1H { <Zt>.H }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer msize = 16;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

### 32-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	1	1	0	0	imm4			1	0	1	Pg			Rn			Zt							
dtype<3:1>dtype<0>																															

LD1H { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

### 64-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	1	1	1	0	imm4			1	0	1	Pg			Rn			Zt							
dtype<3:1>dtype<0>																															

LD1H { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

## Assembler Symbols

<Zt>	Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<imm>	Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + eoff * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LD1H (scalar plus scalar)

Contiguous load unsigned halfwords to vector (scalar index)

Contiguous load of unsigned halfwords to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 2 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 3 classes: [16-bit element](#) , [32-bit element](#) and [64-bit element](#)

### 16-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	1	0	1	Rm				0	1	0	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

LD1H { <Zt>.H }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
integer msize = 16;
boolean unsigned = TRUE;
```

### 32-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	1	1	0	Rm				0	1	0	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

LD1H { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
boolean unsigned = TRUE;
```

### 64-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	1	1	1	Rm				0	1	0	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

LD1H { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
boolean unsigned = TRUE;
```

## Assembler Symbols

<Zt>	Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
bits(64) offset;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = base + (UInt(offset) + e) * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



## LD1H (scalar plus vector)

Gather load unsigned halfwords to vector (vector index)

Gather load of unsigned halfwords to active elements of a vector register from memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then optionally multiplied by 2. Inactive elements will not cause a read from Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 6 classes: [32-bit scaled offset](#) , [32-bit unpacked scaled offset](#) , [32-bit unpacked unscaled offset](#) , [32-bit unscaled offset](#) , [64-bit scaled offset](#) and [64-bit unscaled offset](#)

### 32-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	1	xs	1	Zm					0	1	0	Pg			Rn					Zt				
																U ff															

LD1H { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod> #1]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 1;
```

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	1	xs	1	Zm					0	1	0	Pg			Rn					Zt				
U ff																															

LD1H { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod> #1]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 1;
```

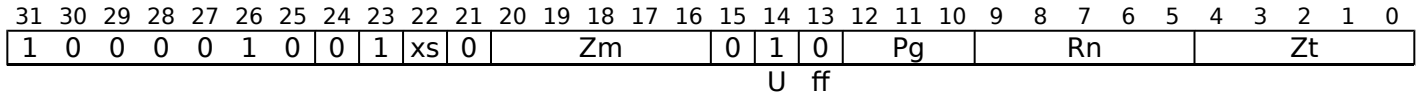
### 32-bit unpacked unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	1	xs	0	Zm					0	1	0	Pg			Rn					Zt				
msz<1>msz<0>																U ff															

LD1H { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

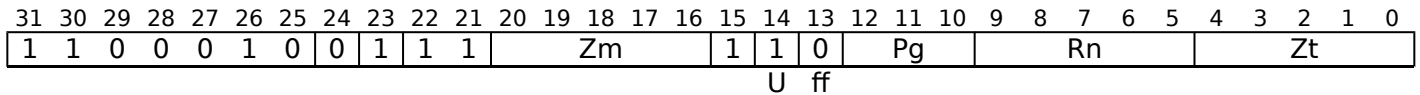
### 32-bit unscaled offset



LD1H { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

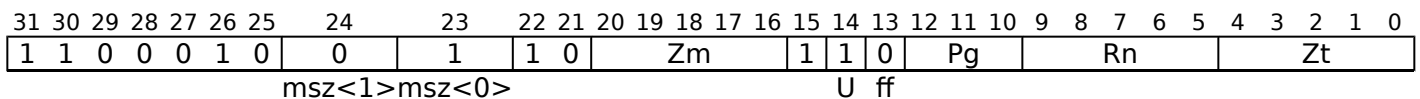
### 64-bit scaled offset



LD1H { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, LSL #1]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 64;
boolean unsigned = TRUE;
boolean offs_unsigned = TRUE;
integer scale = 1;
```

### 64-bit unscaled offset



LD1H { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 64;
boolean unsigned = TRUE;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) offset;
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = Z[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        bits(64) addr = base + (off << scale);
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

## LD1RB

Load and broadcast unsigned byte to vector

Load a single unsigned byte from a memory address generated by a 64-bit scalar base address plus an immediate offset which is in the range 0 to 63.

Broadcast the loaded data into all active elements of the destination vector, setting the inactive elements to zero. If all elements are inactive then the instruction will not perform a read from Device memory or cause a data abort.

It has encodings from 4 classes: [8-bit element](#) , [16-bit element](#) , [32-bit element](#) and [64-bit element](#)

### 8-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	0	1	imm6		1	0	0	Pg	Rn		Zt													
dtypeh<1>dtypeh<0>										dtypel<1>dtypel<0>																					

LD1RB { <Zt>.B }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = UInt(imm6);
```

### 16-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	0	1	imm6			1	0	1	Pg	Rn			Zt											
dtypeh<1>dtypeh<0>										dtypel<1>dtypel<0>																					

LD1RB { <Zt>.H }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = UInt(imm6);
```

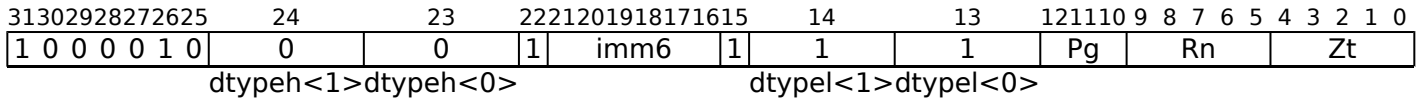
### 32-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	0	1	imm6	1	1	0	Pg	Rn	Zt															
dtypeh<1>dtypeh<0>										dtypel<1>dtypel<0>																					

LD1RB { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = UInt(imm6);
```

## 64-bit element



**LD1RB** { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```

if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = UInt(imm6);

```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional unsigned immediate byte offset, in the range 0 to 63, defaulting to 0, encoded in the "imm6" field.

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        bits(64) addr = base + offset * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

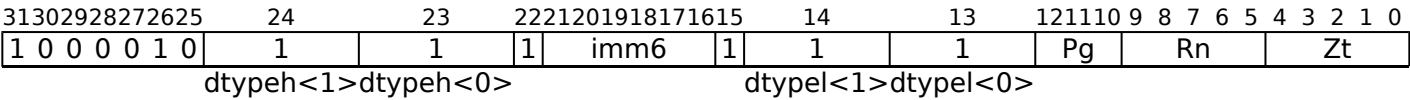
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LD1RD

Load and broadcast doubleword to vector

Load a single doubleword from a memory address generated by a 64-bit scalar base address plus an immediate offset which is a multiple of 8 in the range 0 to 504.

Broadcast the loaded data into all active elements of the destination vector, setting the inactive elements to zero. If all elements are inactive then the instruction will not perform a read from Device memory or cause a data abort.



```
LD1RD { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>}]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
boolean unsigned = TRUE;
integer offset = UInt(imm6);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 8 in the range 0 to 504, defaulting to 0, encoded in the "imm6" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        bits(64) addr = base + offset * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```



## LD1RH

Load and broadcast unsigned halfword to vector

Load a single unsigned halfword from a memory address generated by a 64-bit scalar base address plus an immediate offset which is a multiple of 2 in the range 0 to 126.

Broadcast the loaded data into all active elements of the destination vector, setting the inactive elements to zero. If all elements are inactive then the instruction will not perform a read from Device memory or cause a data abort.

It has encodings from 3 classes: [16-bit element](#) , [32-bit element](#) and [64-bit element](#)

### 16-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	1	imm6						1	0	1	Pg			Rn			Zt							
dtypeh<1>dtypeh<0>								dtypel<1>dtypel<0>																							

LD1RH { <Zt>.H }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer msize = 16;
boolean unsigned = TRUE;
integer offset = UInt(imm6);
```

### 32-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	1	imm6						1	1	0	Pg			Rn			Zt							
dtypeh<1>dtypeh<0>								dtypel<1>dtypel<0>																							

LD1RH { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
boolean unsigned = TRUE;
integer offset = UInt(imm6);
```

### 64-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	1	1	imm6						1	1	1	Pg			Rn			Zt						
dtypeh<1>dtypeh<0>								dtypel<1>dtypel<0>																							

LD1RH { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
boolean unsigned = TRUE;
integer offset = UInt(imm6);
```



## Assembler Symbols

<Zt>	Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<imm>	Is the optional unsigned immediate byte offset, a multiple of 2 in the range 0 to 126, defaulting to 0, encoded in the "imm6" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        bits(64) addr = base + offset * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

LD1ROB (scalar plus immediate)

Contiguous load and replicate thirty-two bytes (immediate index)

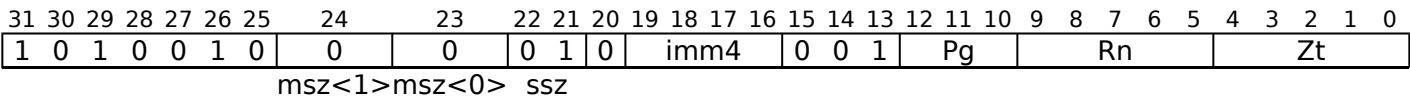
Load thirty-two contiguous bytes to elements of a 256-bit (octaword) vector from the memory address generated by a 64-bit scalar base address and immediate index that is a multiple of 32 in the range -256 to +224 added to the base address.

Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero.

The resulting 256-bit vector is then replicated to fill the destination vector. The instruction requires that the current vector length is at least 256 bits, and if the current vector length is not an integer multiple of 256 bits then the trailing bits in the destination vector are set to zero.

Only the first thirty-two predicate elements are used and higher numbered predicate elements are ignored.

ID\_AA64ZFR0\_EL1.F64MM indicates whether this instruction is implemented.



LD1ROB { <Zt>.B }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVEFP64MatMulExt() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8;
integer offset = SInt(imm4);
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate byte offset, a multiple of 32 in the range -256 to 224, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
if VL < 256 then UNDEFINED;
integer elements = 256 DIV esize;
bits(64) base;
bits(PL) mask = P[g]; // low bits only
bits(256) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + eoff * mbytes;
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();

Z[t] = ZeroExtend(Replicate(result, VL DIV 256), VL);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

LD1ROB (scalar plus scalar)

Contiguous load and replicate thirty-two bytes (scalar index)

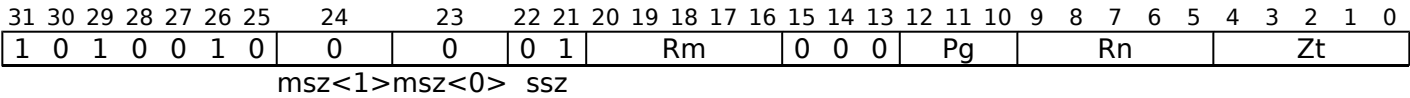
Load thirty-two contiguous bytes to elements of a 256-bit (octaword) vector from the memory address generated by a 64-bit scalar base address and scalar index which is added to the base address.

Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero.

The resulting 256-bit vector is then replicated to fill the destination vector. The instruction requires that the current vector length is at least 256 bits, and if the current vector length is not an integer multiple of 256 bits then the trailing bits in the destination vector are set to zero.

Only the first thirty-two predicate elements are used and higher numbered predicate elements are ignored.

ID\_AA64ZFR0\_EL1.F64MM indicates whether this instruction is implemented.



LD1ROB { <Zt>.B }, <Pg>/Z, [<Xn|SP>, <Xm>]

```
if !HaveSVEFP64MatMulExt() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 8;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
if VL < 256 then UNDEFINED;
integer elements = 256 DIV esize;
bits(64) base;
bits(PL) mask = P[g]; // low bits only
bits(64) offset;
bits(256) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = UInt(offset) + e;
        bits(64) addr = base + eoff * mbytes;
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();

Z[t] = ZeroExtend(Replicate(result, VL DIV 256), VL);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LD1ROD (scalar plus immediate)

Contiguous load and replicate four doublewords (immediate index)

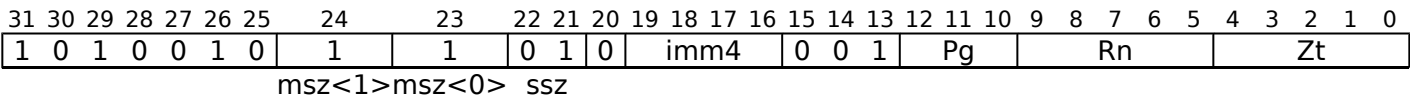
Load four contiguous doublewords to elements of a 256-bit (octaword) vector from the memory address generated by a 64-bit scalar base address and immediate index that is a multiple of 32 in the range -256 to +224 added to the base address.

Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero.

The resulting 256-bit vector is then replicated to fill the destination vector. The instruction requires that the current vector length is at least 256 bits, and if the current vector length is not an integer multiple of 256 bits then the trailing bits in the destination vector are set to zero.

Only the first four predicate elements are used and higher numbered predicate elements are ignored.

ID\_AA64ZFR0\_EL1.F64MM indicates whether this instruction is implemented.



LD1ROD { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVEFP64MatMulExt() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer offset = SInt(imm4);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate byte offset, a multiple of 32 in the range -256 to 224, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
if VL < 256 then UNDEFINED;
integer elements = 256 DIV esize;
bits(64) base;
bits(PL) mask = P[g]; // low bits only
bits(256) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + eoff * mbytes;
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();

Z[t] = ZeroExtend(Replicate(result, VL DIV 256), VL);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LD1ROD (scalar plus scalar)

Contiguous load and replicate four doublewords (scalar index)

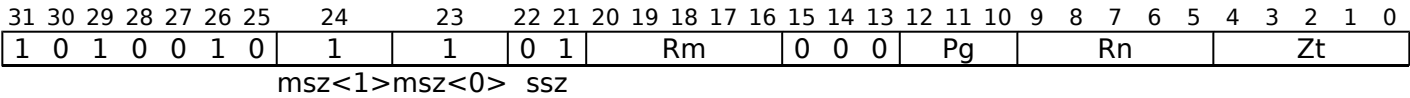
Load four contiguous doublewords to elements of a 256-bit (octaword) vector from the memory address generated by a 64-bit scalar base address and scalar index which is multiplied by 8 and added to the base address.

Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero.

The resulting 256-bit vector is then replicated to fill the destination vector. The instruction requires that the current vector length is at least 256 bits, and if the current vector length is not an integer multiple of 256 bits then the trailing bits in the destination vector are set to zero.

Only the first four predicate elements are used and higher numbered predicate elements are ignored.

ID\_AA64ZFR0\_EL1.F64MM indicates whether this instruction is implemented.



LD1ROD { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #3]

```
if !HaveSVEFP64MatMulExt() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.



## Operation

```
CheckSVEEnabled();
if VL < 256 then UNDEFINED;
integer elements = 256 DIV esize;
bits(64) base;
bits(PL) mask = P[g]; // low bits only
bits(64) offset;
bits(256) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = UInt(offset) + e;
        bits(64) addr = base + eoff * mbytes;
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();

Z[t] = ZeroExtend(Replicate(result, VL DIV 256), VL);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LD1ROH (scalar plus immediate)

Contiguous load and replicate sixteen halfwords (immediate index)

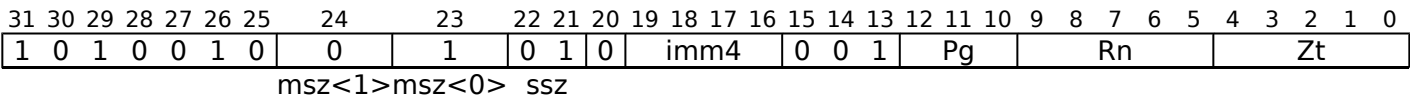
Load sixteen contiguous halfwords to elements of a 256-bit (octaword) vector from the memory address generated by a 64-bit scalar base address and immediate index that is a multiple of 32 in the range -256 to +224 added to the base address.

Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero.

The resulting 256-bit vector is then replicated to fill the destination vector. The instruction requires that the current vector length is at least 256 bits, and if the current vector length is not an integer multiple of 256 bits then the trailing bits in the destination vector are set to zero.

Only the first sixteen predicate elements are used and higher numbered predicate elements are ignored.

ID\_AA64ZFR0\_EL1.F64MM indicates whether this instruction is implemented.



LD1ROH { <Zt>.H }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVEFP64MatMulExt() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer offset = SInt(imm4);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate byte offset, a multiple of 32 in the range -256 to 224, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
if VL < 256 then UNDEFINED;
integer elements = 256 DIV esize;
bits(64) base;
bits(PL) mask = P[g]; // low bits only
bits(256) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + eoff * mbytes;
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();

Z[t] = ZeroExtend(Replicate(result, VL DIV 256), VL);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LD1ROH (scalar plus scalar)

Contiguous load and replicate sixteen halfwords (scalar index)

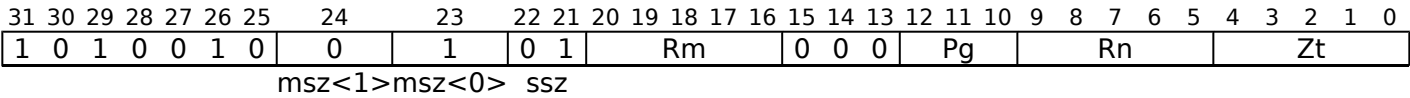
Load sixteen contiguous halfwords to elements of a 256-bit (octaword) vector from the memory address generated by a 64-bit scalar base address and scalar index which is multiplied by 2 and added to the base address.

Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero.

The resulting 256-bit vector is then replicated to fill the destination vector. The instruction requires that the current vector length is at least 256 bits, and if the current vector length is not an integer multiple of 256 bits then the trailing bits in the destination vector are set to zero.

Only the first sixteen predicate elements are used and higher numbered predicate elements are ignored.

ID\_AA64ZFR0\_EL1.F64MM indicates whether this instruction is implemented.



LD1ROH { <Zt>.H }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVEFP64MatMulExt() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
if VL < 256 then UNDEFINED;
integer elements = 256 DIV esize;
bits(64) base;
bits(PL) mask = P[g]; // low bits only
bits(64) offset;
bits(256) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = UInt(offset) + e;
        bits(64) addr = base + eoff * mbytes;
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();

Z[t] = ZeroExtend(Replicate(result, VL DIV 256), VL);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

LD1ROW (scalar plus immediate)

Contiguous load and replicate eight words (immediate index)

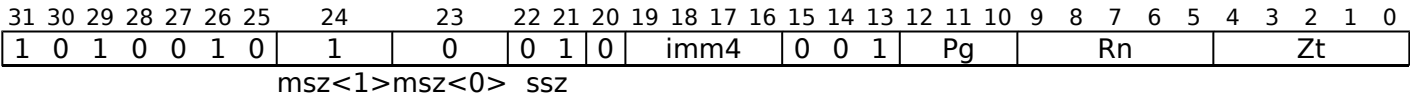
Load eight contiguous words to elements of a 256-bit (octaword) vector from the memory address generated by a 64-bit scalar base address and immediate index that is a multiple of 32 in the range -256 to +224 added to the base address.

Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero.

The resulting 256-bit vector is then replicated to fill the destination vector. The instruction requires that the current vector length is at least 256 bits, and if the current vector length is not an integer multiple of 256 bits then the trailing bits in the destination vector are set to zero.

Only the first eight predicate elements are used and higher numbered predicate elements are ignored.

ID\_AA64ZFR0\_EL1.F64MM indicates whether this instruction is implemented.



```
LD1ROW { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>}]
```

```
if !HaveSVEFP64MatMulExt() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer offset = SInt(imm4);
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate byte offset, a multiple of 32 in the range -256 to 224, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
if VL < 256 then UNDEFINED;
integer elements = 256 DIV esize;
bits(64) base;
bits(PL) mask = P[g]; // low bits only
bits(256) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + eoff * mbytes;
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();

Z[t] = ZeroExtend(Replicate(result, VL DIV 256), VL);
```

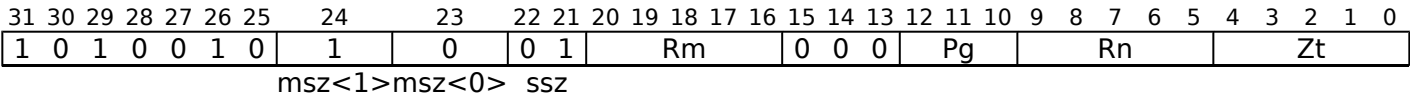
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LD1ROW (scalar plus scalar)

Contiguous load and replicate eight words (scalar index)

Load eight contiguous words to elements of a 256-bit (octaword) vector from the memory address generated by a 64-bit scalar base address and scalar index which is multiplied by 4 and added to the base address. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero. The resulting 256-bit vector is then replicated to fill the destination vector. The instruction requires that the current vector length is at least 256 bits, and if the current vector length is not an integer multiple of 256 bits then the trailing bits in the destination vector are set to zero. Only the first eight predicate elements are used and higher numbered predicate elements are ignored. ID\_AA64ZFR0\_EL1.F64MM indicates whether this instruction is implemented.



LD1ROW { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #2]

```
if !HaveSVEFP64MatMulExt() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.



## Operation

```
CheckSVEEnabled();
if VL < 256 then UNDEFINED;
integer elements = 256 DIV esize;
bits(64) base;
bits(PL) mask = P[g]; // low bits only
bits(64) offset;
bits(256) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = UInt(offset) + e;
        bits(64) addr = base + eoff * mbytes;
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();

Z[t] = ZeroExtend(Replicate(result, VL DIV 256), VL);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

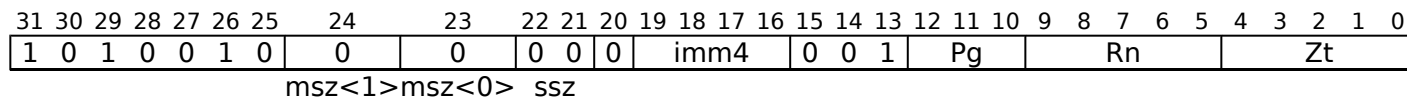
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LD1RQB (scalar plus immediate)

Contiguous load and replicate sixteen bytes (immediate index)

Load sixteen contiguous bytes to elements of a short, 128-bit (quadword) vector from the memory address generated by a 64-bit scalar base address and immediate index that is a multiple of 16 in the range -128 to +112 added to the base address.

Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero. The resulting short vector is then replicated to fill the long destination vector. Only the first sixteen predicate elements are used and higher numbered predicate elements are ignored.



**LD1RQB { <Zt>.B }, <Pg>/Z, [<Xn|SP>{, #<imm>}]**

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8;
integer offset = SInt(imm4);
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate byte offset, a multiple of 16 in the range -128 to 112, defaulting to 0, encoded in the "imm4" field.

### Operation

```
CheckSVEEnabled();
integer elements = 128 DIV esize;
bits(64) base;
bits(PL) mask = P[g]; // low 16 bits only
bits(128) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = base + (offset * 16) + (e * mbytes);
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();

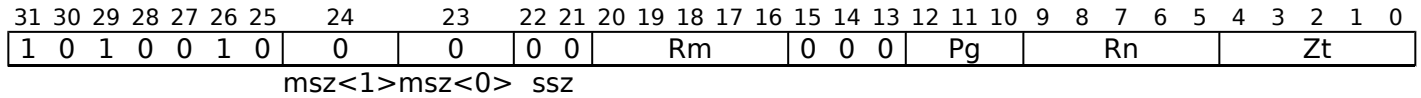
Z[t] = Replicate(result, VL DIV 128);
```

## LD1RQB (scalar plus scalar)

Contiguous load and replicate sixteen bytes (scalar index)

Load sixteen contiguous bytes to elements of a short, 128-bit (quadword) vector from the memory address generated by a 64-bit scalar base address and scalar index which is added to the base address.

Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero. The resulting short vector is then replicated to fill the long destination vector. Only the first sixteen predicate elements are used and higher numbered predicate elements are ignored.



**LD1RQB { <Zt>.B }, <Pg>/Z, [<Xn|SP>, <Xm>]**

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 8;
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

### Operation

```
CheckSVEEnabled();
integer elements = 128 DIV esize;
bits(64) base;
bits(PL) mask = P[g]; // low 16 bits only
bits(64) offset;
bits(128) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = X[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = UInt(offset) + e;
        bits(64) addr = base + eoff * mbytes;
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();

Z[t] = Replicate(result, VL DIV 128);
```

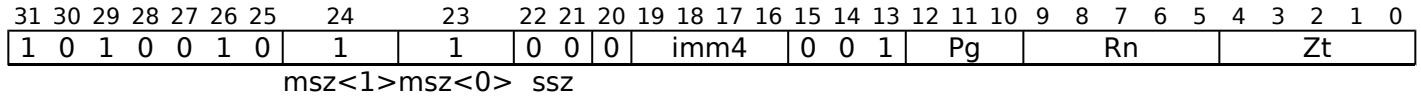


## LD1RQD (scalar plus immediate)

Contiguous load and replicate two doublewords (immediate index)

Load two contiguous doublewords to elements of a short, 128-bit (quadword) vector from the memory address generated by a 64-bit scalar base address and immediate index that is a multiple of 16 in the range -128 to +112 added to the base address.

Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero. The resulting short vector is then replicated to fill the long destination vector. Only the first two predicate elements are used and higher numbered predicate elements are ignored.



**LD1RQD { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>}]**

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer offset = SInt(imm4);
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate byte offset, a multiple of 16 in the range -128 to 112, defaulting to 0, encoded in the "imm4" field.

### Operation

```
CheckSVEEnabled();
integer elements = 128 DIV esize;
bits(64) base;
bits(PL) mask = P[g]; // low 16 bits only
bits(128) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];

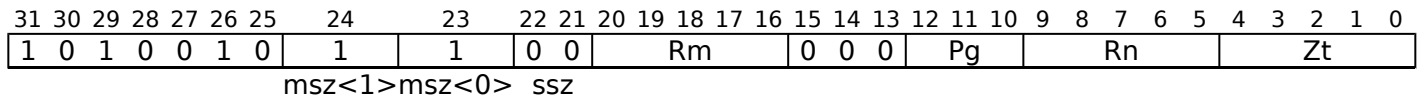
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = base + (offset * 16) + (e * mbytes);
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();

Z[t] = Replicate(result, VL DIV 128);
```

## LD1RQD (scalar plus scalar)

Contiguous load and replicate two doublewords (scalar index)

Load two contiguous doublewords to elements of a short, 128-bit (quadword) vector from the memory address generated by a 64-bit scalar base address and scalar index which is multiplied by 8 and added to the base address. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero. The resulting short vector is then replicated to fill the long destination vector. Only the first two predicate elements are used and higher numbered predicate elements are ignored.



**LD1RQD { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #3]**

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

### Operation

```
CheckSVEEnabled();
integer elements = 128 DIV esize;
bits(64) base;
bits(PL) mask = P[g]; // low 16 bits only
bits(64) offset;
bits(128) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = X[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = UInt(offset) + e;
        bits(64) addr = base + eoff * mbytes;
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();

Z[t] = Replicate(result, VL DIV 128);
```

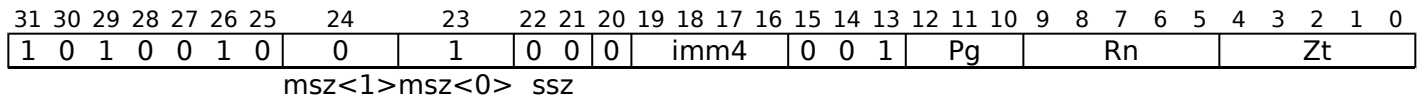


## LD1RQH (scalar plus immediate)

Contiguous load and replicate eight halfwords (immediate index)

Load eight contiguous halfwords to elements of a short, 128-bit (quadword) vector from the memory address generated by a 64-bit scalar base address and immediate index that is a multiple of 16 in the range -128 to +112 added to the base address.

Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero. The resulting short vector is then replicated to fill the long destination vector. Only the first eight predicate elements are used and higher numbered predicate elements are ignored.



**LD1RQH { <Zt>.H }, <Pg>/Z, [<Xn|SP>{, #<imm>}]**

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer offset = SInt(imm4);
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate byte offset, a multiple of 16 in the range -128 to 112, defaulting to 0, encoded in the "imm4" field.

### Operation

```
CheckSVEEnabled();
integer elements = 128 DIV esize;
bits(64) base;
bits(PL) mask = P[g]; // low 16 bits only
bits(128) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = base + (offset * 16) + (e * mbytes);
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();

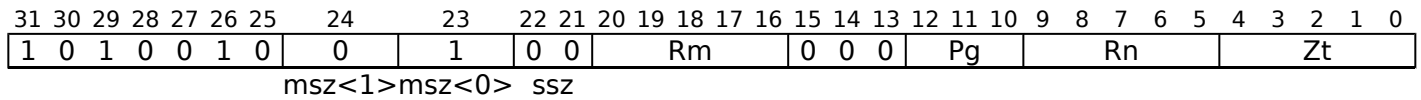
Z[t] = Replicate(result, VL DIV 128);
```



## LD1RQH (scalar plus scalar)

Contiguous load and replicate eight halfwords (scalar index)

Load eight contiguous halfwords to elements of a short, 128-bit (quadword) vector from the memory address generated by a 64-bit scalar base address and scalar index which is multiplied by 2 and added to the base address. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero. The resulting short vector is then replicated to fill the long destination vector. Only the first eight predicate elements are used and higher numbered predicate elements are ignored.



**LD1RQH { <Zt>.H }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #1]**

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

### Operation

```
CheckSVEEnabled();
integer elements = 128 DIV esize;
bits(64) base;
bits(PL) mask = P[g]; // low 16 bits only
bits(64) offset;
bits(128) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = X[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = UInt(offset) + e;
        bits(64) addr = base + eoff * mbytes;
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();

Z[t] = Replicate(result, VL DIV 128);
```

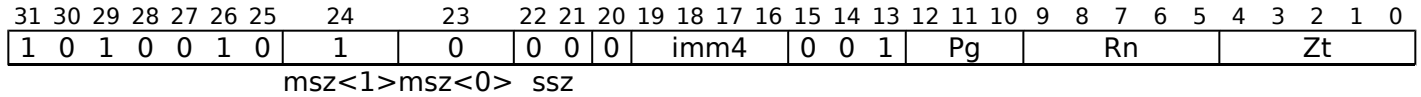


## LD1RQW (scalar plus immediate)

Contiguous load and replicate four words (immediate index)

Load four contiguous words to elements of a short, 128-bit (quadword) vector from the memory address generated by a 64-bit scalar base address and immediate index that is a multiple of 16 in the range -128 to +112 added to the base address.

Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero. The resulting short vector is then replicated to fill the long destination vector. Only the first four predicate elements are used and higher numbered predicate elements are ignored.



LD1RQW { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer offset = SInt(imm4);
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate byte offset, a multiple of 16 in the range -128 to 112, defaulting to 0, encoded in the "imm4" field.

### Operation

```
CheckSVEEnabled();
integer elements = 128 DIV esize;
bits(64) base;
bits(PL) mask = P[g]; // low 16 bits only
bits(128) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = base + (offset * 16) + (e * mbytes);
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();

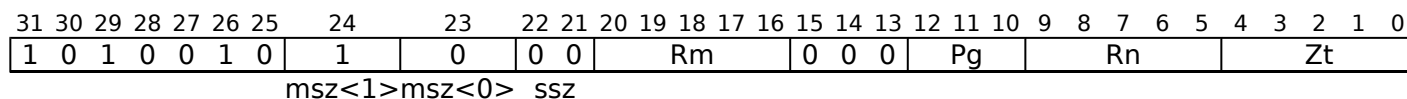
Z[t] = Replicate(result, VL DIV 128);
```

## LD1RQW (scalar plus scalar)

Contiguous load and replicate four words (scalar index)

Load four contiguous words to elements of a short, 128-bit (quadword) vector from the memory address generated by a 64-bit scalar base address and scalar index which is multiplied by 4 and added to the base address.

Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero. The resulting short vector is then replicated to fill the long destination vector. Only the first four predicate elements are used and higher numbered predicate elements are ignored.



**LD1RQW { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #2]**

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

### Operation

```
CheckSVEEnabled();
integer elements = 128 DIV esize;
bits(64) base;
bits(PL) mask = P[g]; // low 16 bits only
bits(64) offset;
bits(128) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = X[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = UInt(offset) + e;
        bits(64) addr = base + eoff * mbytes;
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();

Z[t] = Replicate(result, VL DIV 128);
```



## LD1RSB

Load and broadcast signed byte to vector

Load a single signed byte from a memory address generated by a 64-bit scalar base address plus an immediate offset which is in the range 0 to 63.

Broadcast the loaded data into all active elements of the destination vector, setting the inactive elements to zero. If all elements are inactive then the instruction will not perform a read from Device memory or cause a data abort.

It has encodings from 3 classes: [16-bit element](#) , [32-bit element](#) and [64-bit element](#)

### 16-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	1	1	imm6	1	1	1	0	Pg	Rn	Zt															
dtypeh<1>dtypeh<0>								dtypel<1>dtypel<0>																							

LD1RSB { <Zt>.H }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer msize = 8;
boolean unsigned = FALSE;
integer offset = UInt(imm6);
```

### 32-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	1	1	imm6	1	0	1	Pg	Rn	Zt																
dtypeh<1>dtypeh<0>								dtypel<1>dtypel<0>																							

LD1RSB { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
boolean unsigned = FALSE;
integer offset = UInt(imm6);
```

### 64-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	1	1	imm6	1	0	0	Pg	Rn	Zt																
dtypeh<1>dtypeh<0>								dtypel<1>dtypel<0>																							

LD1RSB { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
boolean unsigned = FALSE;
integer offset = UInt(imm6);
```

## Assembler Symbols

<Zt>	Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<imm>	Is the optional unsigned immediate byte offset, in the range 0 to 63, defaulting to 0, encoded in the "imm6" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        bits(64) addr = base + offset * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

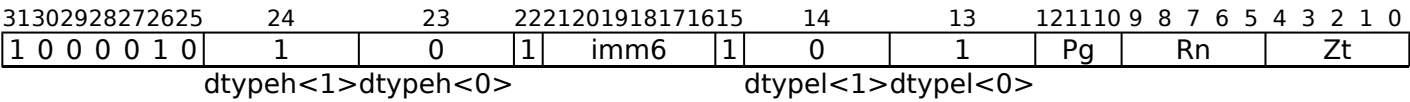
# LD1RSH

Load and broadcast signed halfword to vector

Load a single signed halfword from a memory address generated by a 64-bit scalar base address plus an immediate offset which is a multiple of 2 in the range 0 to 126.  
Broadcast the loaded data into all active elements of the destination vector, setting the inactive elements to zero. If all elements are inactive then the instruction will not perform a read from Device memory or cause a data abort.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

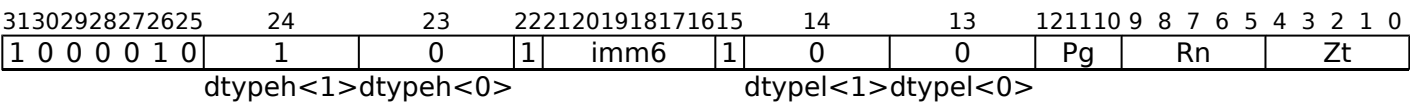
## 32-bit element



LD1RSH { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
boolean unsigned = FALSE;
integer offset = UInt(imm6);
```

## 64-bit element



LD1RSH { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
boolean unsigned = FALSE;
integer offset = UInt(imm6);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 2 in the range 0 to 126, defaulting to 0, encoded in the "imm6" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        bits(64) addr = base + offset * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

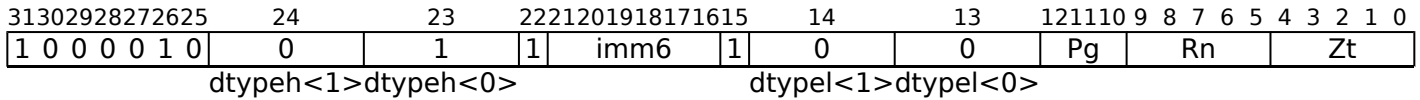
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LD1RSW

Load and broadcast signed word to vector

Load a single signed word from a memory address generated by a 64-bit scalar base address plus an immediate offset which is a multiple of 4 in the range 0 to 252.

Broadcast the loaded data into all active elements of the destination vector, setting the inactive elements to zero. If all elements are inactive then the instruction will not perform a read from Device memory or cause a data abort.



**LD1RSW { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>}]**

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
boolean unsigned = FALSE;
integer offset = UInt(imm6);
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 4 in the range 0 to 252, defaulting to 0, encoded in the "imm6" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        bits(64) addr = base + offset * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```



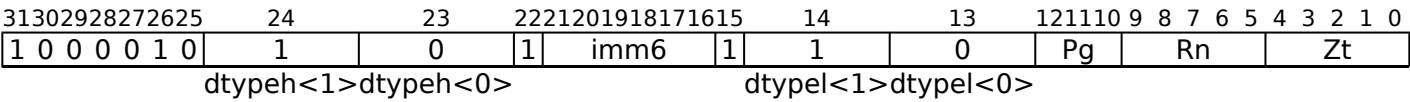
# LD1RW

Load and broadcast unsigned word to vector

Load a single unsigned word from a memory address generated by a 64-bit scalar base address plus an immediate offset which is a multiple of 4 in the range 0 to 252.  
Broadcast the loaded data into all active elements of the destination vector, setting the inactive elements to zero. If all elements are inactive then the instruction will not perform a read from Device memory or cause a data abort.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

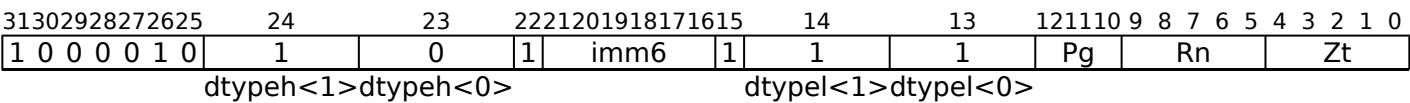
## 32-bit element



LD1RW { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 32;
boolean unsigned = TRUE;
integer offset = UInt(imm6);
```

## 64-bit element



LD1RW { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
boolean unsigned = TRUE;
integer offset = UInt(imm6);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 4 in the range 0 to 252, defaulting to 0, encoded in the "imm6" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        bits(64) addr = base + offset * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

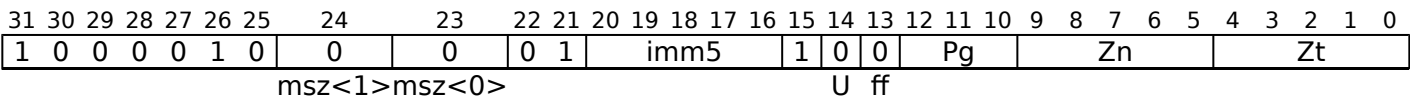
# LD1SB (vector plus immediate)

Gather load signed bytes to vector (immediate index)

Gather load of signed bytes to active elements of a vector register from memory addresses generated by a vector base plus immediate index. The index is in the range 0 to 31. Inactive elements will not cause a read from Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

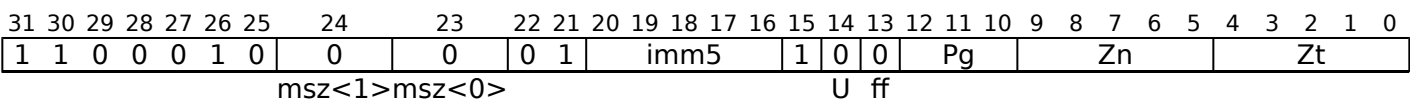
## 32-bit element



LD1SB { <Zt>.S }, <Pg>/Z, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
boolean unsigned = FALSE;
integer offset = UInt(imm5);
```

## 64-bit element



LD1SB { <Zt>.D }, <Pg>/Z, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
boolean unsigned = FALSE;
integer offset = UInt(imm5);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, in the range 0 to 31, defaulting to 0, encoded in the "imm5" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) base;
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if AnyActiveElement(mask, esize) then
    base = Z[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LD1SB (scalar plus immediate)

Contiguous load signed bytes to vector (immediate index)

Contiguous load of signed bytes to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 3 classes: [16-bit element](#) , [32-bit element](#) and [64-bit element](#)

### 16-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	1	1	1	0	0	imm4				1	0	1	Pg			Rn				Zt					
dtype<3:1>dtype<0>																															

LD1SB { <Zt>.H }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer msize = 8;
boolean unsigned = FALSE;
integer offset = SInt(imm4);
```

### 32-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	1	1	0	1	0	imm4				1	0	1	Pg			Rn				Zt					
dtype<3:1>dtype<0>																															

LD1SB { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
boolean unsigned = FALSE;
integer offset = SInt(imm4);
```

### 64-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	1	1	0	0	0	imm4				1	0	1	Pg			Rn				Zt					
dtype<3:1>dtype<0>																															

LD1SB { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
boolean unsigned = FALSE;
integer offset = SInt(imm4);
```



## Assembler Symbols

<Zt>	Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<imm>	Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + eoff * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LD1SB (scalar plus scalar)

Contiguous load signed bytes to vector (scalar index)

Contiguous load of signed bytes to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 3 classes: [16-bit element](#) , [32-bit element](#) and [64-bit element](#)

### 16-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	1	1	1	0	Rm				0	1	0	Pg				Rn				Zt					
dtype<3:1>dtype<0>																															

LD1SB { <Zt>.H }, <Pg>/Z, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
integer msize = 8;
boolean unsigned = FALSE;
```

### 32-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	1	1	0	1	Rm				0	1	0	Pg				Rn				Zt					
dtype<3:1>dtype<0>																															

LD1SB { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
boolean unsigned = FALSE;
```

### 64-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	1	1	0	0	Rm				0	1	0	Pg				Rn				Zt					
dtype<3:1>dtype<0>																															

LD1SB { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
boolean unsigned = FALSE;
```

## Assembler Symbols

<Zt>	Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
bits(64) offset;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = base + (UInt(offset) + e) * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LD1SB (scalar plus vector)

Gather load signed bytes to vector (vector index)

Gather load of signed bytes to active elements of a vector register from memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally sign or zero-extended from 32 to 64 bits. Inactive elements will not cause a read from Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 3 classes: [32-bit unpacked unscaled offset](#) , [32-bit unscaled offset](#) and [64-bit unscaled offset](#)

### 32-bit unpacked unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	xs	0	Zm				0	0	0	Pg			Rn				Zt						
msz<1>msz<0>										U										ff											

**LD1SB** { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

### 32-bit unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	0	xs	0	Zm				0	0	0	Pg			Rn				Zt						
										U										ff											

**LD1SB** { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

### 64-bit unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	1	0	Zm				1	0	0	Pg			Rn				Zt						
msz<1>msz<0>										U ff																					

LD1SB { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
integer offs_size = 64;
boolean unsigned = FALSE;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) offset;
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = Z[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        bits(64) addr = base + (off << scale);
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

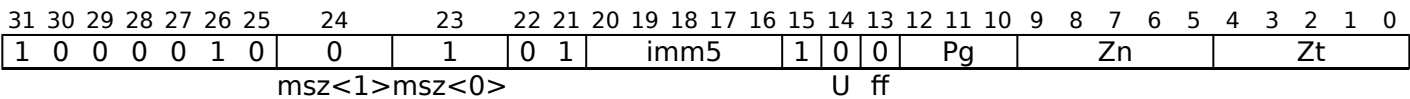
# LD1SH (vector plus immediate)

Gather load signed halfwords to vector (immediate index)

Gather load of signed halfwords to active elements of a vector register from memory addresses generated by a vector base plus immediate index. The index is a multiple of 2 in the range 0 to 62. Inactive elements will not cause a read from Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

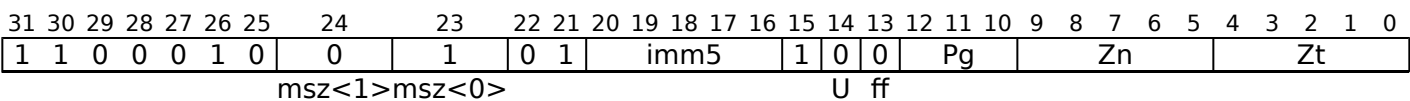
## 32-bit element



LD1SH { <Zt>.S }, <Pg>/Z, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
boolean unsigned = FALSE;
integer offset = UInt(imm5);
```

## 64-bit element



LD1SH { <Zt>.D }, <Pg>/Z, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
boolean unsigned = FALSE;
integer offset = UInt(imm5);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 2 in the range 0 to 62, defaulting to 0, encoded in the "imm5" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) base;
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if AnyActiveElement(mask, esize) then
    base = Z[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

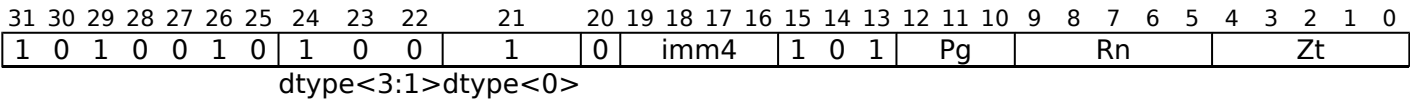
# LD1SH (scalar plus immediate)

Contiguous load signed halfwords to vector (immediate index)

Contiguous load of signed halfwords to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

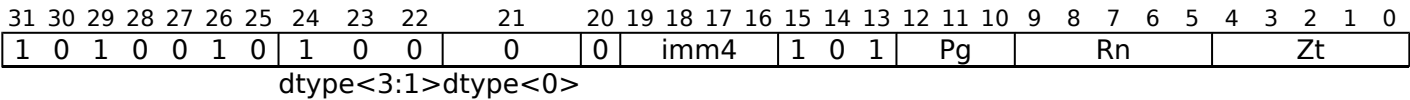
## 32-bit element



LD1SH { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
boolean unsigned = FALSE;
integer offset = SInt(imm4);
```

## 64-bit element



LD1SH { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
boolean unsigned = FALSE;
integer offset = SInt(imm4);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + eoff * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

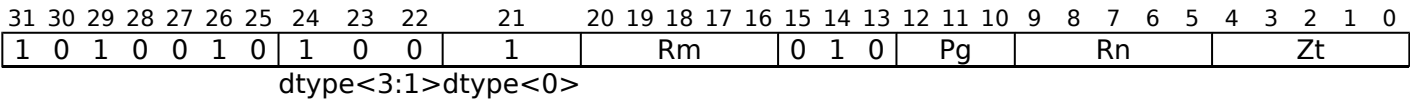
# LD1SH (scalar plus scalar)

Contiguous load signed halfwords to vector (scalar index)

Contiguous load of signed halfwords to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 2 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

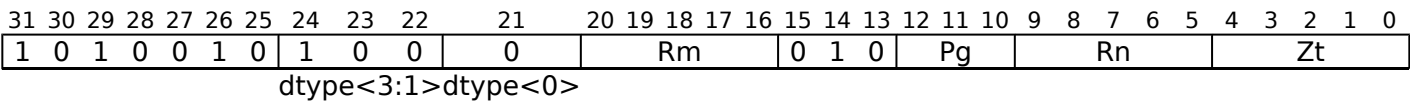
## 32-bit element



LD1SH { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
boolean unsigned = FALSE;
```

## 64-bit element



LD1SH { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
boolean unsigned = FALSE;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
bits(64) offset;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = X[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = base + (UInt(offset) + e) * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LD1SH (scalar plus vector)

Gather load signed halfwords to vector (vector index)

Gather load of signed halfwords to active elements of a vector register from memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then optionally multiplied by 2. Inactive elements will not cause a read from Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 6 classes: [32-bit scaled offset](#) , [32-bit unpacked scaled offset](#) , [32-bit unpacked unscaled offset](#) , [32-bit unscaled offset](#) , [64-bit scaled offset](#) and [64-bit unscaled offset](#)

### 32-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	1	xs	1	Zm				0	0	0	Pg			Rn				Zt						
																U				ff											

LD1SH { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod> #1]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 1;
```

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	1	xs	1	Zm				0	0	0	Pg			Rn				Zt						
																U				ff											

LD1SH { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod> #1]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 1;
```

### 32-bit unpacked unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	1	xs	0	Zm				0	0	0	Pg			Rn				Zt						
msz<1>msz<0>																U ff															

LD1SH { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

### 32-bit unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	1	xs	0	Zm				0	0	0	Pg			Rn				Zt						
																U				ff											

LD1SH { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

### 64-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	1	1	1	Zm				1	0	0	Pg			Rn				Zt						
																U				ff											

LD1SH { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, LSL #1]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 64;
boolean unsigned = FALSE;
boolean offs_unsigned = TRUE;
integer scale = 1;
```

### 64-bit unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	1	1	0	Zm				1	0	0	Pg			Rn				Zt						
msz<1>msz<0>																U ff															

LD1SH { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 64;
boolean unsigned = FALSE;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) offset;
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = Z[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        bits(64) addr = base + (off << scale);
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

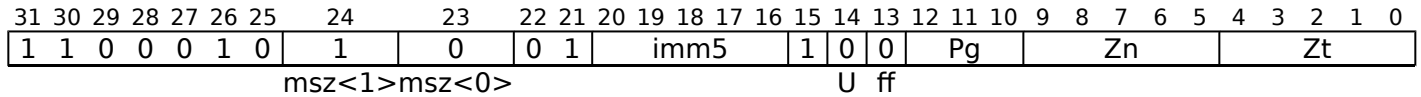
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LD1SW (vector plus immediate)

Gather load signed words to vector (immediate index)

Gather load of signed words to active elements of a vector register from memory addresses generated by a vector base plus immediate index. The index is a multiple of 4 in the range 0 to 124. Inactive elements will not cause a read from Device memory or signal faults, and are set to zero in the destination vector.



**LD1SW** { <Zt>.D }, <Pg>/Z, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
boolean unsigned = FALSE;
integer offset = UInt(imm5);
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 4 in the range 0 to 124, defaulting to 0, encoded in the "imm5" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) base;
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if AnyActiveElement(mask, esize) then
    base = Z[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

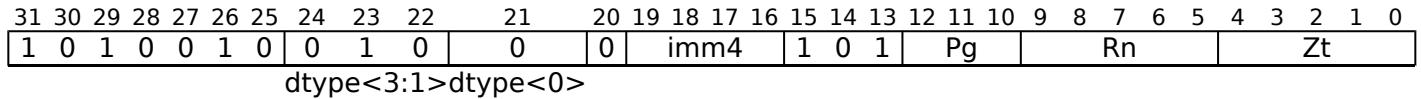
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LD1SW (scalar plus immediate)

Contiguous load signed words to vector (immediate index)

Contiguous load of signed words to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.



**LD1SW { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]**

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
boolean unsigned = FALSE;
integer offset = SInt(imm4);
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + eoff * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

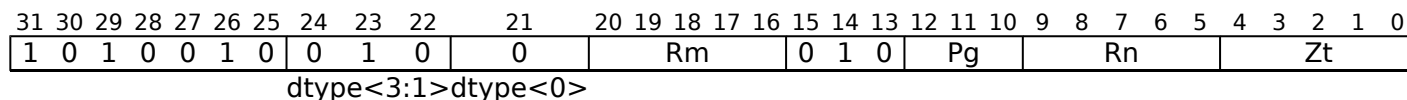




## LD1SW (scalar plus scalar)

Contiguous load signed words to vector (scalar index)

Contiguous load of signed words to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 4 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.



**LD1SW { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #2]**

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
boolean unsigned = FALSE;
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
bits(64) offset;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = base + (UInt(offset) + e) * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```



## LD1SW (scalar plus vector)

Gather load signed words to vector (vector index)

Gather load of signed words to active elements of a vector register from memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then optionally multiplied by 4. Inactive elements will not cause a read from Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 4 classes: [32-bit unpacked scaled offset](#) , [32-bit unpacked unscaled offset](#) , [64-bit scaled offset](#) and [64-bit unscaled offset](#)

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	1	0	xs	1	Zm					0	0	0	Pg			Rn					Zt				
																U				ff											

LD1SW { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod> #2]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 2;
```

### 32-bit unpacked unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
1	1	0	0	0	1	0	1	0	xs	0	Zm					0	0	0	Pg			Rn					Zt								
msz<1>msz<0>																U												ff							

LD1SW { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

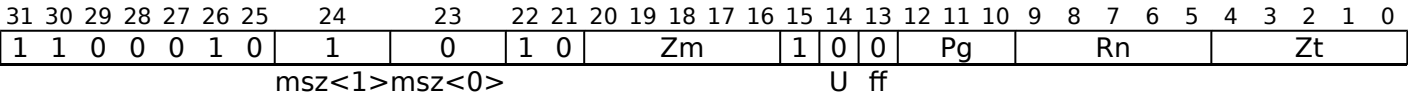
### 64-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	1	0	1	1	Zm					1	0	0	Pg			Rn					Zt				
																U				ff											

LD1SW { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, LSL #2]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 64;
boolean unsigned = FALSE;
boolean offs_unsigned = TRUE;
integer scale = 2;
```

64-bit unscaled offset



LD1SW { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 64;
boolean unsigned = FALSE;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) offset;
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = Z[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        bits(64) addr = base + (off << scale);
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

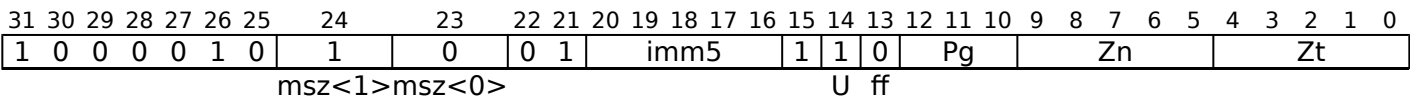
# LD1W (vector plus immediate)

Gather load unsigned words to vector (immediate index)

Gather load of unsigned words to active elements of a vector register from memory addresses generated by a vector base plus immediate index. The index is a multiple of 4 in the range 0 to 124. Inactive elements will not cause a read from Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

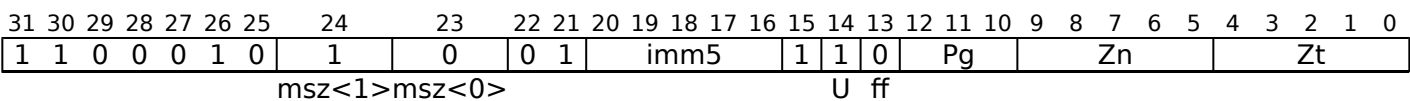
## 32-bit element



LD1W { <Zt>.S }, <Pg>/Z, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 32;
boolean unsigned = TRUE;
integer offset = UInt(imm5);
```

## 64-bit element



LD1W { <Zt>.D }, <Pg>/Z, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
boolean unsigned = TRUE;
integer offset = UInt(imm5);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 4 in the range 0 to 124, defaulting to 0, encoded in the "imm5" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) base;
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if AnyActiveElement(mask, esize) then
    base = Z[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



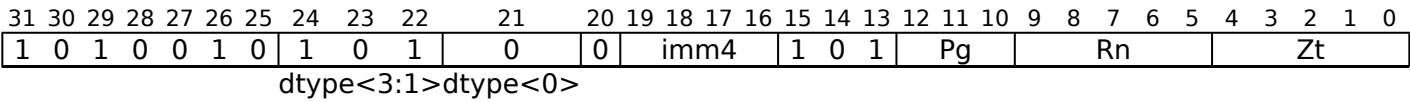
# LD1W (scalar plus immediate)

Contiguous load unsigned words to vector (immediate index)

Contiguous load of unsigned words to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

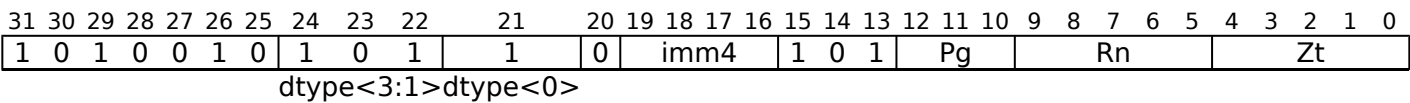
## 32-bit element



LD1W { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 32;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

## 64-bit element



LD1W { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + eoff * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

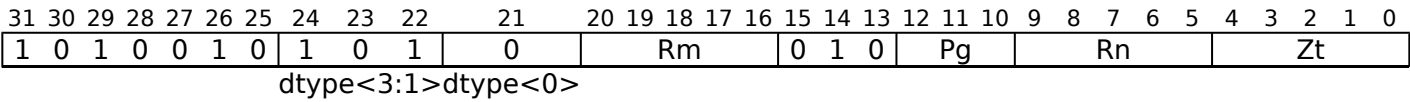
# LD1W (scalar plus scalar)

Contiguous load unsigned words to vector (scalar index)

Contiguous load of unsigned words to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 4 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

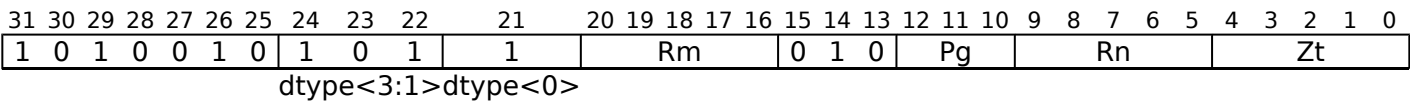
## 32-bit element



LD1W { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #2]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 32;
boolean unsigned = TRUE;
```

## 64-bit element



LD1W { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #2]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
boolean unsigned = TRUE;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
bits(64) offset;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = X[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = base + (UInt(offset) + e) * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LD1W (scalar plus vector)

Gather load unsigned words to vector (vector index)

Gather load of unsigned words to active elements of a vector register from memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then optionally multiplied by 4. Inactive elements will not cause a read from Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 6 classes: [32-bit scaled offset](#) , [32-bit unpacked scaled offset](#) , [32-bit unpacked unscaled offset](#) , [32-bit unscaled offset](#) , [64-bit scaled offset](#) and [64-bit unscaled offset](#)

### 32-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	1	0	xs	1	Zm				0	1	0	Pg			Rn				Zt						
																U		ff													

LD1W { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod> #2]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 32;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 2;
```

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	1	0	xs	1	Zm				0	1	0	Pg			Rn				Zt						
																U		ff													

LD1W { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod> #2]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 2;
```

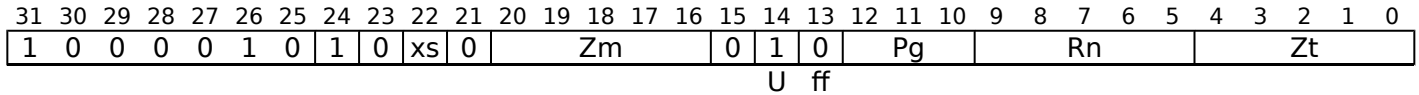
### 32-bit unpacked unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	1	0	xs	0	Zm				0	1	0	Pg			Rn				Zt						
msz<1>msz<0>																U ff															

LD1W { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

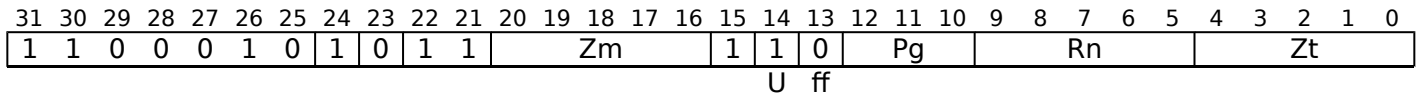
### 32-bit unscaled offset



LD1W { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 32;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

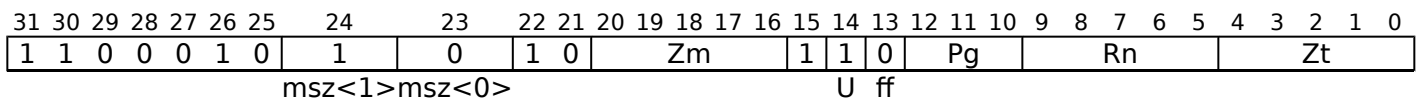
### 64-bit scaled offset



LD1W { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, LSL #2]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 64;
boolean unsigned = TRUE;
boolean offs_unsigned = TRUE;
integer scale = 2;
```

### 64-bit unscaled offset



LD1W { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 64;
boolean unsigned = TRUE;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) offset;
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = Z[m];

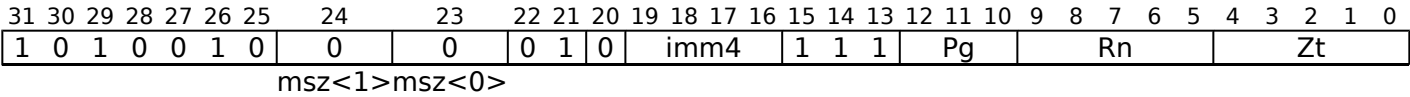
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        bits(64) addr = base + (off << scale);
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

LD2B (scalar plus immediate)

Contiguous load two-byte structures to two vectors (immediate index)

Contiguous load two-byte structures, each to the same element number in two vector registers from the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 2 in the range -16 to 14 that is multiplied by the vector's in-memory size, irrespective of predication,  
Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive bytes in memory which make up each structure. Inactive elements will not cause a read from Device memory or signal a fault, and the corresponding element is set to zero in each of the two destination vector registers.



```
LD2B { <Zt1>.B, <Zt2>.B }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8;
integer offset = SInt(imm4);
integer nreg = 2;
```

Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 2 in the range -16 to 14, defaulting to 0, encoded in the "imm4" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = (offset * elements * nreg) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

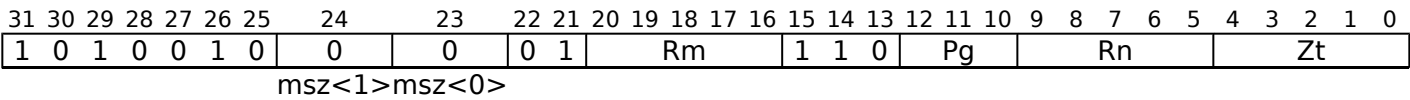
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LD2B (scalar plus scalar)

Contiguous load two-byte structures to two vectors (scalar index)

Contiguous load two-byte structures, each to the same element number in two vector registers from the memory address generated by a 64-bit scalar base and a 64-bit scalar index register and added to the base address. After each structure access the index value is incremented by two. The index register is not updated by the instruction. Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive bytes in memory which make up each structure. Inactive elements will not cause a read from Device memory or signal a fault, and the corresponding element is set to zero in each of the two destination vector registers.



LD2B { <Zt1>.B, <Zt2>.B }, <Pg>/Z, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 8;
integer nreg = 2;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(64) offset;
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = UInt(offset) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

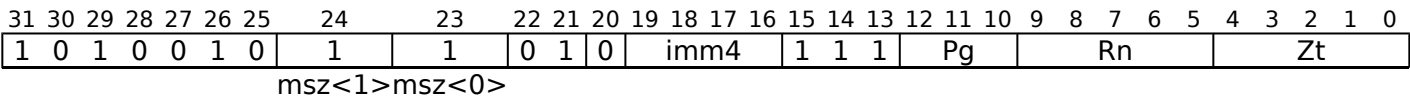
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LD2D (scalar plus immediate)

Contiguous load two-doubleword structures to two vectors (immediate index)

Contiguous load two-doubleword structures, each to the same element number in two vector registers from the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 2 in the range -16 to 14 that is multiplied by the vector's in-memory size, irrespective of predication, Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive doublewords in memory which make up each structure. Inactive elements will not cause a read from Device memory or signal a fault, and the corresponding element is set to zero in each of the two destination vector registers.



LD2D { <Zt1>.D, <Zt2>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer offset = SInt(imm4);
integer nreg = 2;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 2 in the range -16 to 14, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = (offset * elements * nreg) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

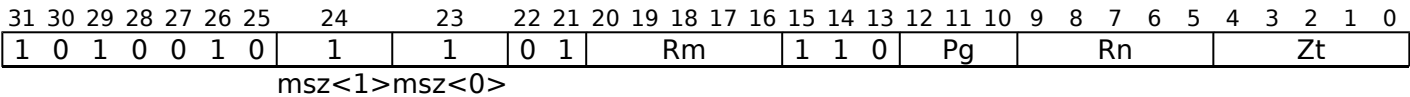
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LD2D (scalar plus scalar)

Contiguous load two-doubleword structures to two vectors (scalar index)

Contiguous load two-doubleword structures, each to the same element number in two vector registers from the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by two. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive doublewords in memory which make up each structure. Inactive elements will not cause a read from Device memory or signal a fault, and the corresponding element is set to zero in each of the two destination vector registers.



LD2D { <Zt1>.D, <Zt2>.D }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #3]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer nreg = 2;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(64) offset;
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = X[m];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = UInt(offset) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

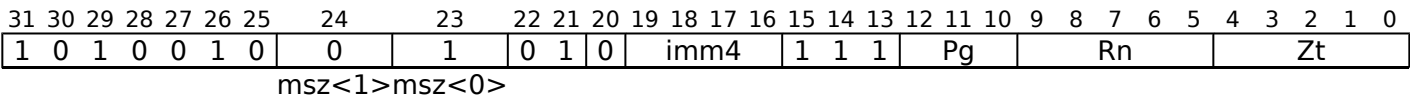
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LD2H (scalar plus immediate)

Contiguous load two-halfword structures to two vectors (immediate index)

Contiguous load two-halfword structures, each to the same element number in two vector registers from the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 2 in the range -16 to 14 that is multiplied by the vector's in-memory size, irrespective of predication,

Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive halfwords in memory which make up each structure. Inactive elements will not cause a read from Device memory or signal a fault, and the corresponding element is set to zero in each of the two destination vector registers.



LD2H { <Zt1>.H, <Zt2>.H }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer offset = SInt(imm4);
integer nreg = 2;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 2 in the range -16 to 14, defaulting to 0, encoded in the "imm4" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = (offset * elements * nreg) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

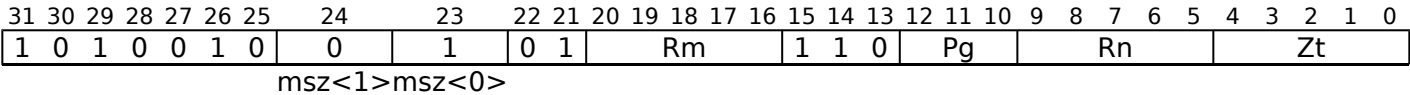
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LD2H (scalar plus scalar)

Contiguous load two-halfword structures to two vectors (scalar index)

Contiguous load two-halfword structures, each to the same element number in two vector registers from the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by two. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive halfwords in memory which make up each structure. Inactive elements will not cause a read from Device memory or signal a fault, and the corresponding element is set to zero in each of the two destination vector registers.



LD2H { <Zt1>.H, <Zt2>.H }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
integer nreg = 2;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(64) offset;
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = X[m];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = UInt(offset) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

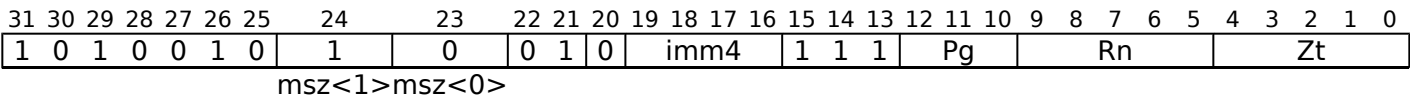
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LD2W (scalar plus immediate)

Contiguous load two-word structures to two vectors (immediate index)

Contiguous load two-word structures, each to the same element number in two vector registers from the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 2 in the range -16 to 14 that is multiplied by the vector's in-memory size, irrespective of predication,

Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive words in memory which make up each structure. Inactive elements will not cause a read from Device memory or signal a fault, and the corresponding element is set to zero in each of the two destination vector registers.



LD2W { <Zt1>.S, <Zt2>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer offset = SInt(imm4);
integer nreg = 2;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 2 in the range -16 to 14, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = (offset * elements * nreg) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

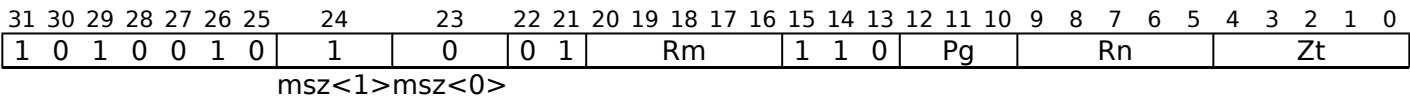
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LD2W (scalar plus scalar)

Contiguous load two-word structures to two vectors (scalar index)

Contiguous load two-word structures, each to the same element number in two vector registers from the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by two. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive words in memory which make up each structure. Inactive elements will not cause a read from Device memory or signal a fault, and the corresponding element is set to zero in each of the two destination vector registers.



LD2W { <Zt1>.S, <Zt2>.S }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #2]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer nreg = 2;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(64) offset;
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = UInt(offset) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

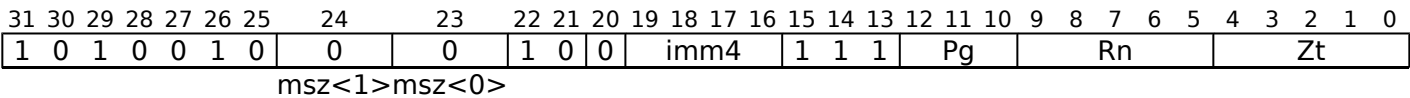
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LD3B (scalar plus immediate)

Contiguous load three-byte structures to three vectors (immediate index)

Contiguous load three-byte structures, each to the same element number in three vector registers from the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 3 in the range -24 to 21 that is multiplied by the vector's in-memory size, irrespective of predication,  
Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive bytes in memory which make up each structure. Inactive elements will not cause a read from Device memory or signal a fault, and the corresponding element is set to zero in each of the three destination vector registers.



LD3B { <Zt1>.B, <Zt2>.B, <Zt3>.B }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8;
integer offset = SInt(imm4);
integer nreg = 3;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 3 in the range -24 to 21, defaulting to 0, encoded in the "imm4" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = (offset * elements * nreg) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

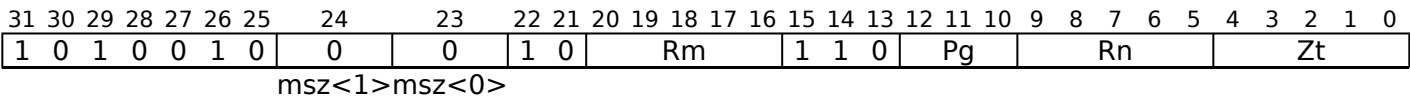
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LD3B (scalar plus scalar)

Contiguous load three-byte structures to three vectors (scalar index)

Contiguous load three-byte structures, each to the same element number in three vector registers from the memory address generated by a 64-bit scalar base and a 64-bit scalar index register and added to the base address. After each structure access the index value is incremented by three. The index register is not updated by the instruction. Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive bytes in memory which make up each structure. Inactive elements will not cause a read from Device memory or signal a fault, and the corresponding element is set to zero in each of the three destination vector registers.



LD3B { <Zt1>.B, <Zt2>.B, <Zt3>.B }, <Pg>/Z, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 8;
integer nreg = 3;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(64) offset;
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = X[m];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = UInt(offset) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

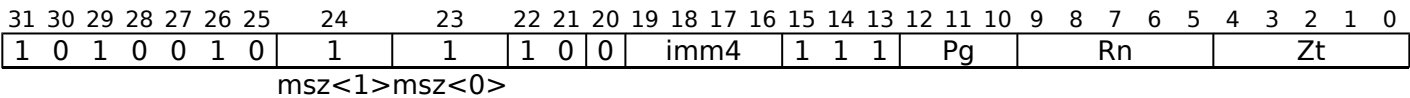
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LD3D (scalar plus immediate)

Contiguous load three-doubleword structures to three vectors (immediate index)

Contiguous load three-doubleword structures, each to the same element number in three vector registers from the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 3 in the range -24 to 21 that is multiplied by the vector's in-memory size, irrespective of predication, Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive doublewords in memory which make up each structure. Inactive elements will not cause a read from Device memory or signal a fault, and the corresponding element is set to zero in each of the three destination vector registers.



LD3D { <Zt1>.D, <Zt2>.D, <Zt3>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer offset = SInt(imm4);
integer nreg = 3;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 3 in the range -24 to 21, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = (offset * elements * nreg) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

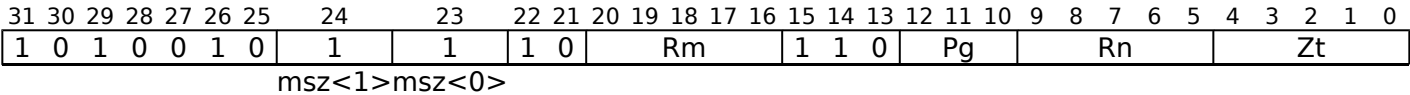
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LD3D (scalar plus scalar)

Contiguous load three-doubleword structures to three vectors (scalar index)

Contiguous load three-doubleword structures, each to the same element number in three vector registers from the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by three. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive doublewords in memory which make up each structure. Inactive elements will not cause a read from Device memory or signal a fault, and the corresponding element is set to zero in each of the three destination vector registers.



LD3D { <Zt1>.D, <Zt2>.D, <Zt3>.D }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #3]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer nreg = 3;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(64) offset;
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = X[m];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = UInt(offset) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

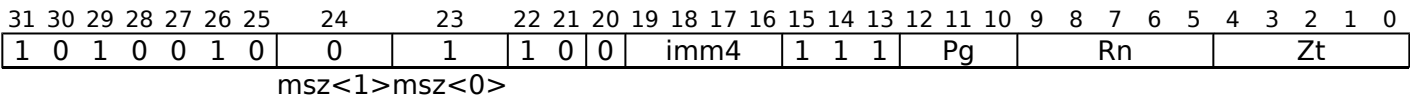
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LD3H (scalar plus immediate)

Contiguous load three-halfword structures to three vectors (immediate index)

Contiguous load three-halfword structures, each to the same element number in three vector registers from the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 3 in the range -24 to 21 that is multiplied by the vector's in-memory size, irrespective of predication, Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive halfwords in memory which make up each structure. Inactive elements will not cause a read from Device memory or signal a fault, and the corresponding element is set to zero in each of the three destination vector registers.



LD3H { <Zt1>.H, <Zt2>.H, <Zt3>.H }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer offset = SInt(imm4);
integer nreg = 3;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 3 in the range -24 to 21, defaulting to 0, encoded in the "imm4" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = (offset * elements * nreg) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

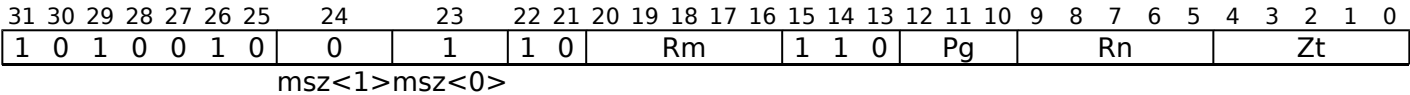
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LD3H (scalar plus scalar)

Contiguous load three-halfword structures to three vectors (scalar index)

Contiguous load three-halfword structures, each to the same element number in three vector registers from the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by three. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive halfwords in memory which make up each structure. Inactive elements will not cause a read from Device memory or signal a fault, and the corresponding element is set to zero in each of the three destination vector registers.



LD3H { <Zt1>.H, <Zt2>.H, <Zt3>.H }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
integer nreg = 3;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(64) offset;
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = X[m];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = UInt(offset) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

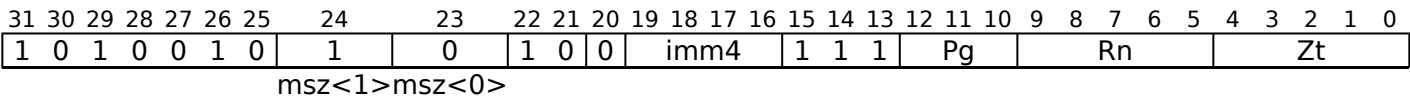
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LD3W (scalar plus immediate)

Contiguous load three-word structures to three vectors (immediate index)

Contiguous load three-word structures, each to the same element number in three vector registers from the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 3 in the range -24 to 21 that is multiplied by the vector's in-memory size, irrespective of predication, Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive words in memory which make up each structure. Inactive elements will not cause a read from Device memory or signal a fault, and the corresponding element is set to zero in each of the three destination vector registers.



LD3W { <Zt1>.S, <Zt2>.S, <Zt3>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer offset = SInt(imm4);
integer nreg = 3;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 3 in the range -24 to 21, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = (offset * elements * nreg) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

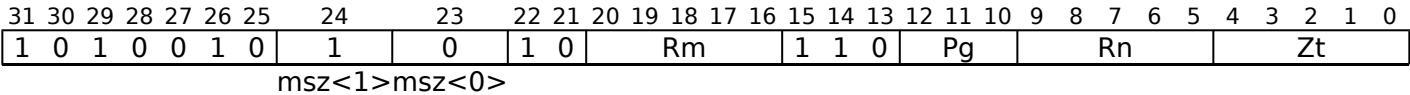
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LD3W (scalar plus scalar)

Contiguous load three-word structures to three vectors (scalar index)

Contiguous load three-word structures, each to the same element number in three vector registers from the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by three. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive words in memory which make up each structure. Inactive elements will not cause a read from Device memory or signal a fault, and the corresponding element is set to zero in each of the three destination vector registers.



LD3W { <Zt1>.S, <Zt2>.S, <Zt3>.S }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #2]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer nreg = 3;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(64) offset;
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = X[m];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = UInt(offset) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

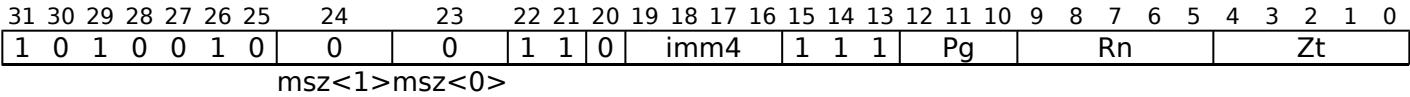
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LD4B (scalar plus immediate)

Contiguous load four-byte structures to four vectors (immediate index)

Contiguous load four-byte structures, each to the same element number in four vector registers from the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 4 in the range -32 to 28 that is multiplied by the vector's in-memory size, irrespective of predication,

Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive bytes in memory which make up each structure. Inactive elements will not cause a read from Device memory or signal a fault, and the corresponding element is set to zero in each of the four destination vector registers.



LD4B { <Zt1>.B, <Zt2>.B, <Zt3>.B, <Zt4>.B }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8;
integer offset = SInt(imm4);
integer nreg = 4;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 4 in the range -32 to 28, defaulting to 0, encoded in the "imm4" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = (offset * elements * nreg) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

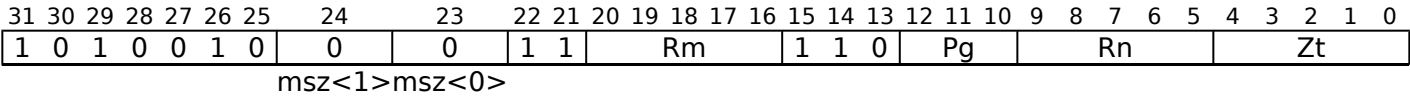
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LD4B (scalar plus scalar)

Contiguous load four-byte structures to four vectors (scalar index)

Contiguous load four-byte structures, each to the same element number in four vector registers from the memory address generated by a 64-bit scalar base and a 64-bit scalar index register and added to the base address. After each structure access the index value is incremented by four. The index register is not updated by the instruction. Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive bytes in memory which make up each structure. Inactive elements will not cause a read from Device memory or signal a fault, and the corresponding element is set to zero in each of the four destination vector registers.



LD4B { <Zt1>.B, <Zt2>.B, <Zt3>.B, <Zt4>.B }, <Pg>/Z, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 8;
integer nreg = 4;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(64) offset;
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = UInt(offset) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

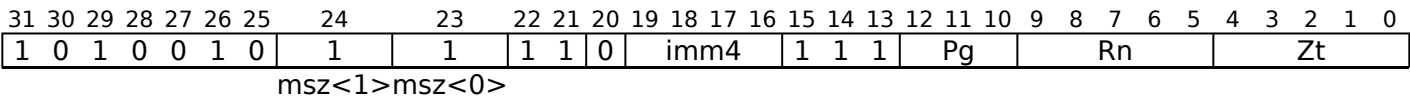
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LD4D (scalar plus immediate)

Contiguous load four-doubleword structures to four vectors (immediate index)

Contiguous load four-doubleword structures, each to the same element number in four vector registers from the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 4 in the range -32 to 28 that is multiplied by the vector's in-memory size, irrespective of predication,

Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive doublewords in memory which make up each structure. Inactive elements will not cause a read from Device memory or signal a fault, and the corresponding element is set to zero in each of the four destination vector registers.



LD4D { <Zt1>.D, <Zt2>.D, <Zt3>.D, <Zt4>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer offset = SInt(imm4);
integer nreg = 4;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 4 in the range -32 to 28, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = (offset * elements * nreg) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

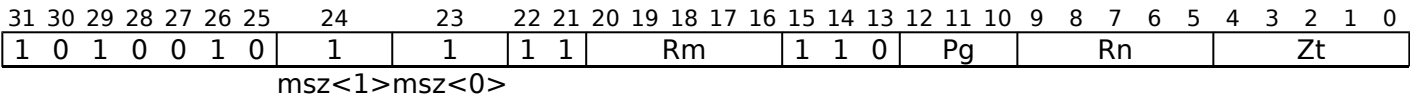
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LD4D (scalar plus scalar)

Contiguous load four-doubleword structures to four vectors (scalar index)

Contiguous load four-doubleword structures, each to the same element number in four vector registers from the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by four. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive doublewords in memory which make up each structure. Inactive elements will not cause a read from Device memory or signal a fault, and the corresponding element is set to zero in each of the four destination vector registers.



LD4D { <Zt1>.D, <Zt2>.D, <Zt3>.D, <Zt4>.D }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #3]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer nreg = 4;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(64) offset;
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = X[m];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = UInt(offset) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

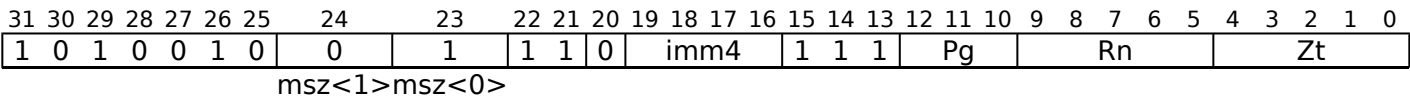
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LD4H (scalar plus immediate)

Contiguous load four-halfword structures to four vectors (immediate index)

Contiguous load four-halfword structures, each to the same element number in four vector registers from the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 4 in the range -32 to 28 that is multiplied by the vector's in-memory size, irrespective of predication, Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive halfwords in memory which make up each structure. Inactive elements will not cause a read from Device memory or signal a fault, and the corresponding element is set to zero in each of the four destination vector registers.



LD4H { <Zt1>.H, <Zt2>.H, <Zt3>.H, <Zt4>.H }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer offset = SInt(imm4);
integer nreg = 4;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 4 in the range -32 to 28, defaulting to 0, encoded in the "imm4" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = (offset * elements * nreg) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

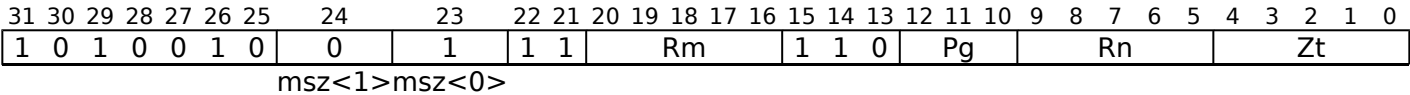
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LD4H (scalar plus scalar)

Contiguous load four-halfword structures to four vectors (scalar index)

Contiguous load four-halfword structures, each to the same element number in four vector registers from the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by four. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive halfwords in memory which make up each structure. Inactive elements will not cause a read from Device memory or signal a fault, and the corresponding element is set to zero in each of the four destination vector registers.



LD4H { <Zt1>.H, <Zt2>.H, <Zt3>.H, <Zt4>.H }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
integer nreg = 4;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(64) offset;
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = X[m];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = UInt(offset) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

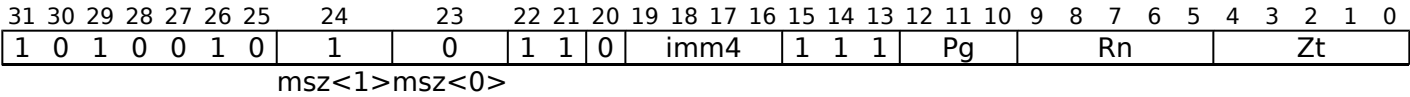
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LD4W (scalar plus immediate)

Contiguous load four-word structures to four vectors (immediate index)

Contiguous load four-word structures, each to the same element number in four vector registers from the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 4 in the range -32 to 28 that is multiplied by the vector's in-memory size, irrespective of predication,

Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive words in memory which make up each structure. Inactive elements will not cause a read from Device memory or signal a fault, and the corresponding element is set to zero in each of the four destination vector registers.



```
LD4W { <Zt1>.S, <Zt2>.S, <Zt3>.S, <Zt4>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer offset = SInt(imm4);
integer nreg = 4;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 4 in the range -32 to 28, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = (offset * elements * nreg) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

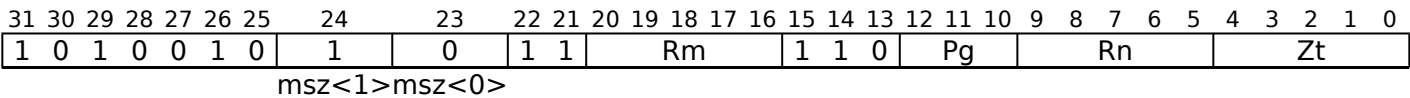
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LD4W (scalar plus scalar)

Contiguous load four-word structures to four vectors (scalar index)

Contiguous load four-word structures, each to the same element number in four vector registers from the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by four. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive words in memory which make up each structure. Inactive elements will not cause a read from Device memory or signal a fault, and the corresponding element is set to zero in each of the four destination vector registers.



```
LD4W { <Zt1>.S, <Zt2>.S, <Zt3>.S, <Zt4>.S }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #2]
```

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer nreg = 4;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(64) offset;
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = UInt(offset) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

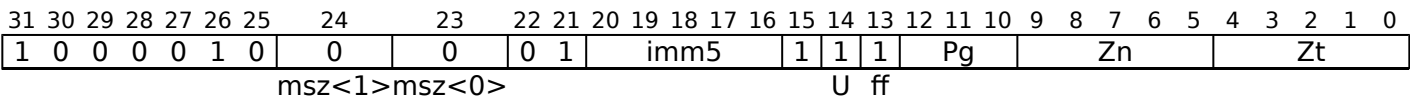
# LDFF1B (vector plus immediate)

Gather load first-fault unsigned bytes to vector (immediate index)

Gather load with first-faulting behavior of unsigned bytes to active elements of a vector register from memory addresses generated by a vector base plus immediate index. The index is in the range 0 to 31. Inactive elements will not cause a read from Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

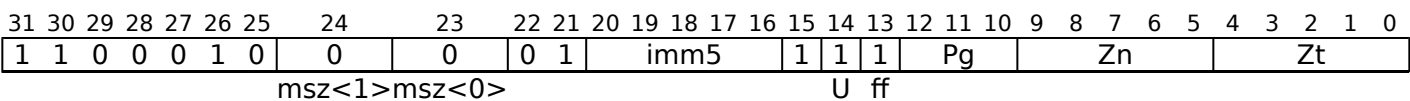
## 32-bit element



LDFF1B { <Zt>.S }, <Pg>/Z, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = UInt(imm5);
```

## 64-bit element



LDFF1B { <Zt>.D }, <Pg>/Z, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = UInt(imm5);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, in the range 0 to 31, defaulting to 0, encoded in the "imm5" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) base;
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if AnyActiveElement(mask, esize) then
    base = Z[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LDFF1B (scalar plus scalar)

Contiguous load first-fault unsigned bytes to vector (scalar index)

Contiguous load with first-faulting behavior of unsigned bytes to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 4 classes: [8-bit element](#) , [16-bit element](#) , [32-bit element](#) and [64-bit element](#)

### 8-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	0	0	0	Rm				0	1	1	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

LDFF1B { <Zt>.B }, <Pg>/Z, [<Xn|SP>{, <Xm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 8;
integer msize = 8;
boolean unsigned = TRUE;
```

### 16-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	0	0	1	Rm				0	1	1	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

LDFF1B { <Zt>.H }, <Pg>/Z, [<Xn|SP>{, <Xm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
integer msize = 8;
boolean unsigned = TRUE;
```

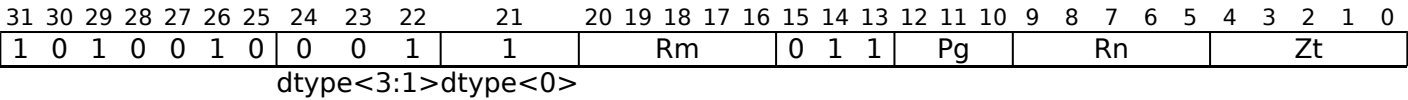
### 32-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	0	1	0	Rm				0	1	1	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

LDFF1B { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, <Xm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
boolean unsigned = TRUE;
```

64-bit element



```
LDFF1B { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, <Xm>}]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
boolean unsigned = TRUE;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the optional 64-bit name of the general-purpose offset register, defaulting to XZR, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
bits(64) offset;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = base + (UInt(offset) + e) * mbytes;
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_NOTFIRST];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LDFF1B (scalar plus vector)

Gather load first-fault unsigned bytes to vector (vector index)

Gather load with first-faulting behavior of unsigned bytes to active elements of a vector register from memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally sign or zero-extended from 32 to 64 bits. Inactive elements will not cause a read from Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 3 classes: [32-bit unpacked unscaled offset](#) , [32-bit unscaled offset](#) and [64-bit unscaled offset](#)

### 32-bit unpacked unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	xs	0	Zm				0	1	1	Pg			Rn				Zt						
msz<1>msz<0>																U												ff			

LDFF1B { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

### 32-bit unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	0	xs	0	Zm				0	1	1	Pg			Rn				Zt						
																U		ff													

LDFF1B { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

### 64-bit unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	1	0	Zm				1	1	1	Pg			Rn				Zt						
msz<1>msz<0>																U ff															

**LDFF1B { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D]**

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
integer offs_size = 64;
boolean unsigned = TRUE;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

**Assembler Symbols**

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in “xs”:

xs	<mod>
0	UXTW
1	SXTW

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;
bits(VL) offset;
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = Z[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        bits(64) addr = base + (off << scale);
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

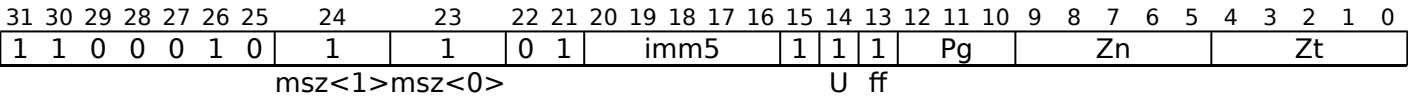
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

**LDFF1D (vector plus immediate)**

Gather load first-fault doublewords to vector (immediate index)

Gather load with first-faulting behavior of doublewords to active elements of a vector register from memory addresses generated by a vector base plus immediate index. The index is a multiple of 8 in the range 0 to 248. Inactive elements will not cause a read from Device memory or signal faults, and are set to zero in the destination vector.



```
LDFF1D { <Zt>.D }, <Pg>/Z, [<Zn>.D{, #<imm>}]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
boolean unsigned = TRUE;
integer offset = UInt(imm5);
```

**Assembler Symbols**

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 8 in the range 0 to 248, defaulting to 0, encoded in the "imm5" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) base;
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if AnyActiveElement(mask, esize) then
    base = Z[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

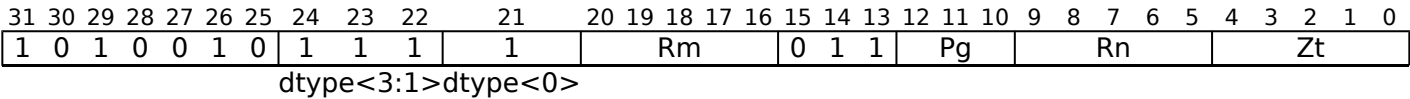
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

LDF1D (scalar plus scalar)

Contiguous load first-fault doublewords to vector (scalar index)

Contiguous load with first-faulting behavior of doublewords to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 8 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.



```
LDF1D { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, <Xm>, LSL #3}]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
boolean unsigned = TRUE;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the optional 64-bit name of the general-purpose offset register, defaulting to XZR, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
bits(64) offset;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = X[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = base + (UInt(offset) + e) * mbytes;
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_NOTFIRST];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LDFF1D (scalar plus vector)

Gather load first-fault doublewords to vector (vector index)

Gather load with first-faulting behavior of doublewords to active elements of a vector register from memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then optionally multiplied by 8. Inactive elements will not cause a read from Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 4 classes: [32-bit unpacked scaled offset](#) , [32-bit unpacked unscaled offset](#) , [64-bit scaled offset](#) and [64-bit unscaled offset](#)

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	1	1	xs	1	Zm					0	1	1	Pg			Rn					Zt				
																	U		ff												

LDFF1D { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod> #3]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 3;
```

### 32-bit unpacked unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	1	1	xs	0	Zm					0	1	1	Pg			Rn					Zt				
msz<1>msz<0>																	U ff														

LDFF1D { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

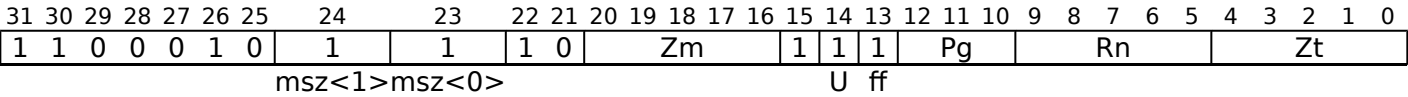
### 64-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	1	1	1	1	Zm					1	1	1	Pg			Rn					Zt				
																	U		ff												

LDFF1D { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, LSL #3]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
integer offs_size = 64;
boolean unsigned = TRUE;
boolean offs_unsigned = TRUE;
integer scale = 3;
```

64-bit unscaled offset



LDFF1D { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
integer offs_size = 64;
boolean unsigned = TRUE;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;
bits(VL) offset;
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = Z[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        bits(64) addr = base + (off << scale);
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

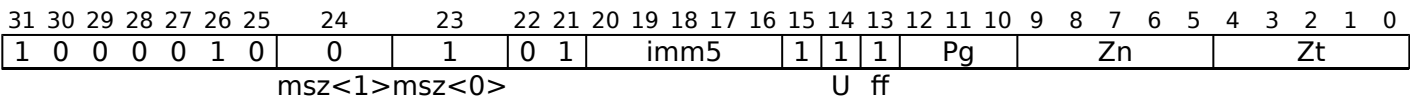
# LDFF1H (vector plus immediate)

Gather load first-fault unsigned halfwords to vector (immediate index)

Gather load with first-faulting behavior of unsigned halfwords to active elements of a vector register from memory addresses generated by a vector base plus immediate index. The index is a multiple of 2 in the range 0 to 62. Inactive elements will not cause a read from Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

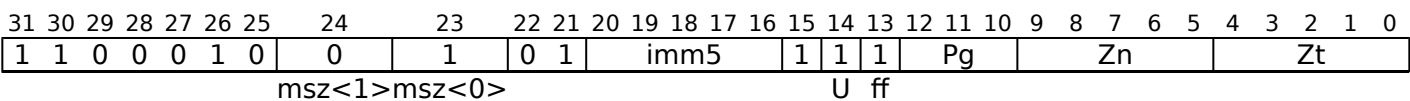
## 32-bit element



LDFF1H { <Zt>.S }, <Pg>/Z, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
boolean unsigned = TRUE;
integer offset = UInt(imm5);
```

## 64-bit element



LDFF1H { <Zt>.D }, <Pg>/Z, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
boolean unsigned = TRUE;
integer offset = UInt(imm5);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 2 in the range 0 to 62, defaulting to 0, encoded in the "imm5" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) base;
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if AnyActiveElement(mask, esize) then
    base = Z[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



## LDFF1H (scalar plus scalar)

Contiguous load first-fault unsigned halfwords to vector (scalar index)

Contiguous load with first-faulting behavior of unsigned halfwords to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 2 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 3 classes: [16-bit element](#) , [32-bit element](#) and [64-bit element](#)

### 16-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	1	0	1	Rm				0	1	1	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

LDFF1H { <Zt>.H }, <Pg>/Z, [<Xn|SP>{, <Xm>, LSL #1}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
integer msize = 16;
boolean unsigned = TRUE;
```

### 32-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	1	1	0	Rm				0	1	1	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

LDFF1H { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, <Xm>, LSL #1}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
boolean unsigned = TRUE;
```

### 64-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	1	1	1	Rm				0	1	1	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

LDFF1H { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, <Xm>, LSL #1}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
boolean unsigned = TRUE;
```

## Assembler Symbols

<Zt>	Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<Xm>	Is the optional 64-bit name of the general-purpose offset register, defaulting to XZR, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
bits(64) offset;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = X[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = base + (UInt(offset) + e) * mbytes;
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_NOTFIRST];
    else
        (data, fault) = (Zeros(msize), FALSE);

// FFR elements set to FALSE following a suppressed access/fault
faulted = faulted || fault;
if faulted then
    ElemFFR[e, esize] = '0';

// Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
unknown = unknown || ElemFFR[e, esize] == '0';
if unknown then
    if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
        Elem[result, e, esize] = Zeros();
    else // merge
        Elem[result, e, esize] = Elem[orig, e, esize];
else
    Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```



## LDF1H (scalar plus vector)

Gather load first-fault unsigned halfwords to vector (vector index)

Gather load with first-faulting behavior of unsigned halfwords to active elements of a vector register from memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then optionally multiplied by 2. Inactive elements will not cause a read from Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 6 classes: [32-bit scaled offset](#) , [32-bit unpacked scaled offset](#) , [32-bit unpacked unscaled offset](#) , [32-bit unscaled offset](#) , [64-bit scaled offset](#) and [64-bit unscaled offset](#)

### 32-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	1	xs	1	Zm					0	1	1	Pg			Rn				Zt					
																U ff															

LDF1H { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod> #1]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 1;
```

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	1	xs	1	Zm					0	1	1	Pg			Rn				Zt					
U ff																															

LDF1H { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod> #1]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 1;
```

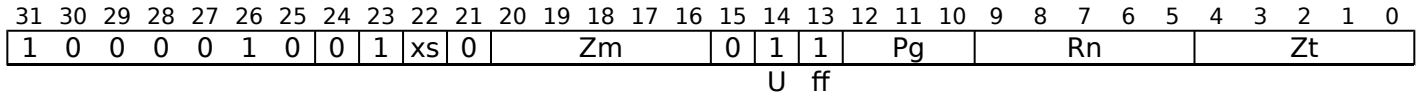
### 32-bit unpacked unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	1	xs	0	Zm					0	1	1	Pg			Rn				Zt					
msz<1>msz<0>																U ff															

LDFF1H { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

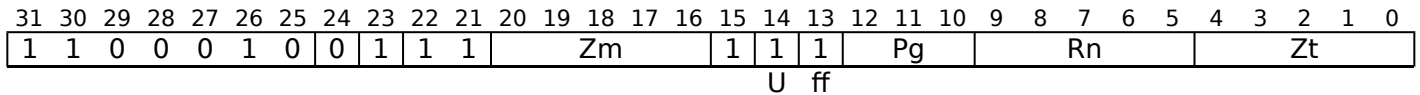
### 32-bit unscaled offset



LDFF1H { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

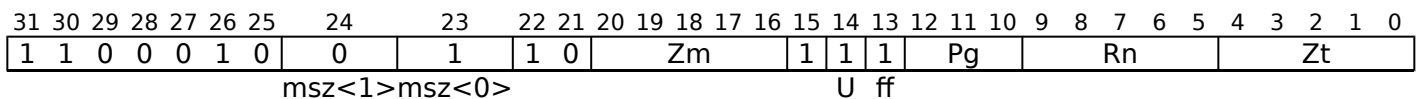
### 64-bit scaled offset



LDFF1H { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, LSL #1]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 64;
boolean unsigned = TRUE;
boolean offs_unsigned = TRUE;
integer scale = 1;
```

### 64-bit unscaled offset



LDF1H { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 64;
boolean unsigned = TRUE;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;
bits(VL) offset;
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = Z[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        bits(64) addr = base + (off << scale);
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

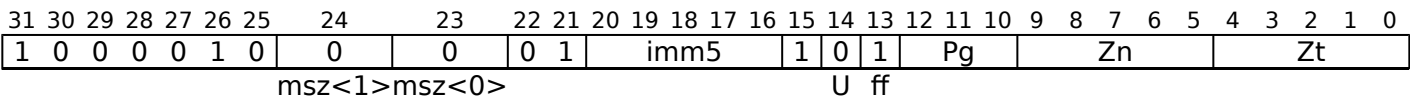
# LDFF1SB (vector plus immediate)

Gather load first-fault signed bytes to vector (immediate index)

Gather load with first-faulting behavior of signed bytes to active elements of a vector register from memory addresses generated by a vector base plus immediate index. The index is in the range 0 to 31. Inactive elements will not cause a read from Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

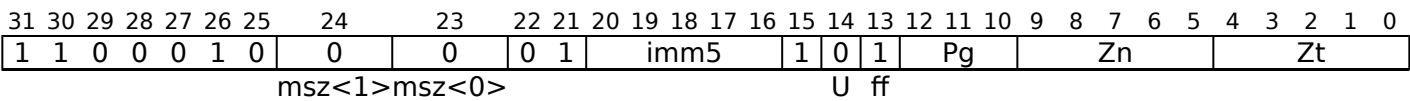
## 32-bit element



LDFF1SB { <Zt>.S }, <Pg>/Z, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
boolean unsigned = FALSE;
integer offset = UInt(imm5);
```

## 64-bit element



LDFF1SB { <Zt>.D }, <Pg>/Z, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
boolean unsigned = FALSE;
integer offset = UInt(imm5);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, in the range 0 to 31, defaulting to 0, encoded in the "imm5" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) base;
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if AnyActiveElement(mask, esize) then
    base = Z[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LDFF1SB (scalar plus scalar)

Contiguous load first-fault signed bytes to vector (scalar index)

Contiguous load with first-faulting behavior of signed bytes to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 3 classes: [16-bit element](#) , [32-bit element](#) and [64-bit element](#)

### 16-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	1	1	1	0	Rm				0	1	1	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

LDFF1SB { <Zt>.H }, <Pg>/Z, [<Xn|SP>{, <Xm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
integer msize = 8;
boolean unsigned = FALSE;
```

### 32-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	1	1	0	1	Rm				0	1	1	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

LDFF1SB { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, <Xm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
boolean unsigned = FALSE;
```

### 64-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	1	1	0	0	Rm				0	1	1	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

LDFF1SB { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, <Xm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
boolean unsigned = FALSE;
```

## Assembler Symbols

<Zt>	Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<Xm>	Is the optional 64-bit name of the general-purpose offset register, defaulting to XZR, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
bits(64) offset;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = X[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = base + (UInt(offset) + e) * mbytes;
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_NOTFIRST];
    else
        (data, fault) = (Zeros(msize), FALSE);

// FFR elements set to FALSE following a suppressed access/fault
faulted = faulted || fault;
if faulted then
    ElemFFR[e, esize] = '0';

// Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
unknown = unknown || ElemFFR[e, esize] == '0';
if unknown then
    if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
        Elem[result, e, esize] = Zeros();
    else // merge
        Elem[result, e, esize] = Elem[orig, e, esize];
else
    Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```



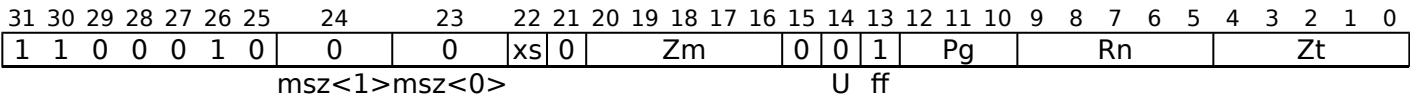
# LDFF1SB (scalar plus vector)

Gather load first-fault signed bytes to vector (vector index)

Gather load with first-faulting behavior of signed bytes to active elements of a vector register from memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally sign or zero-extended from 32 to 64 bits. Inactive elements will not cause a read from Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 3 classes: [32-bit unpacked unscaled offset](#) , [32-bit unscaled offset](#) and [64-bit unscaled offset](#)

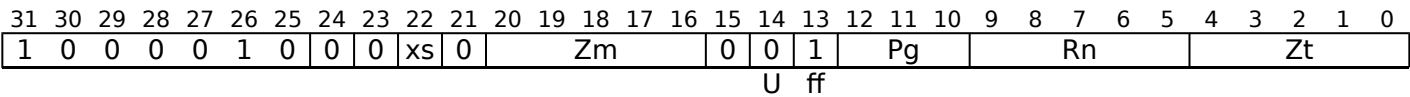
## 32-bit unpacked unscaled offset



LDFF1SB { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

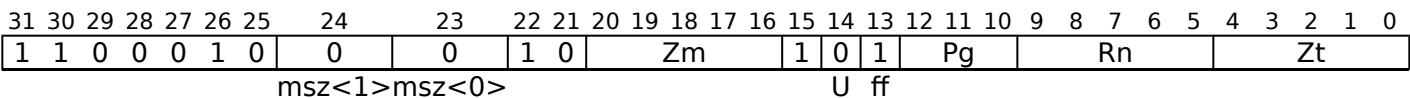
## 32-bit unscaled offset



LDFF1SB { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

## 64-bit unscaled offset



LDDFF1SB { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
integer offs_size = 64;
boolean unsigned = FALSE;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;
bits(VL) offset;
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = Z[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        bits(64) addr = base + (off << scale);
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

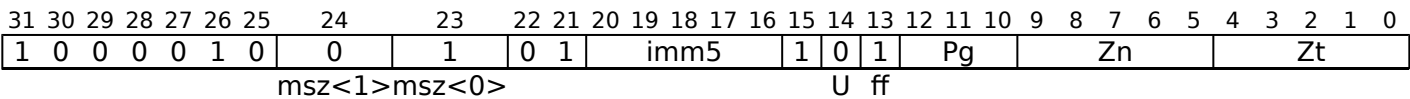
# LDFF1SH (vector plus immediate)

Gather load first-fault signed halfwords to vector (immediate index)

Gather load with first-faulting behavior of signed halfwords to active elements of a vector register from memory addresses generated by a vector base plus immediate index. The index is a multiple of 2 in the range 0 to 62. Inactive elements will not cause a read from Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

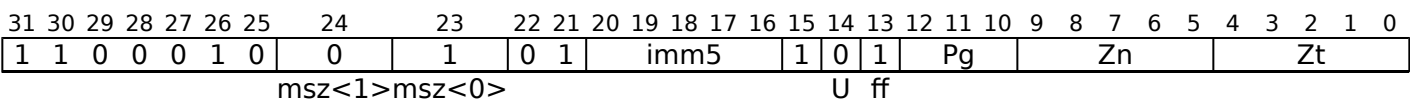
## 32-bit element



LDFF1SH { <Zt>.S }, <Pg>/Z, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
boolean unsigned = FALSE;
integer offset = UInt(imm5);
```

## 64-bit element



LDFF1SH { <Zt>.D }, <Pg>/Z, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
boolean unsigned = FALSE;
integer offset = UInt(imm5);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 2 in the range 0 to 62, defaulting to 0, encoded in the "imm5" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) base;
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if AnyActiveElement(mask, esize) then
    base = Z[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

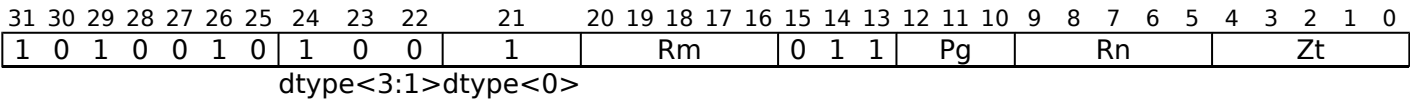
# LDFF1SH (scalar plus scalar)

Contiguous load first-fault signed halfwords to vector (scalar index)

Contiguous load with first-faulting behavior of signed halfwords to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 2 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

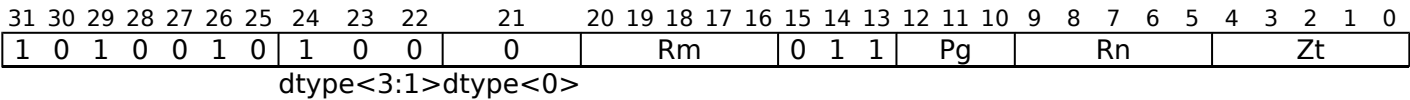
## 32-bit element



LDFF1SH { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, <Xm>, LSL #1}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
boolean unsigned = FALSE;
```

## 64-bit element



LDFF1SH { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, <Xm>, LSL #1}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
boolean unsigned = FALSE;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the optional 64-bit name of the general-purpose offset register, defaulting to XZR, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
bits(64) offset;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = base + (UInt(offset) + e) * mbytes;
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_NOTFIRST];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LDFF1SH (scalar plus vector)

Gather load first-fault signed halfwords to vector (vector index)

Gather load with first-faulting behavior of signed halfwords to active elements of a vector register from memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then optionally multiplied by 2. Inactive elements will not cause a read from Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 6 classes: [32-bit scaled offset](#) , [32-bit unpacked scaled offset](#) , [32-bit unpacked unscaled offset](#) , [32-bit unscaled offset](#) , [64-bit scaled offset](#) and [64-bit unscaled offset](#)

### 32-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	1	xs	1	Zm					0	0	1	Pg			Rn					Zt				
										U ff																					

LDFF1SH { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod> #1]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 1;
```

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	1	xs	1	Zm					0	0	1	Pg			Rn					Zt				
										U ff																					

LDFF1SH { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod> #1]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 1;
```

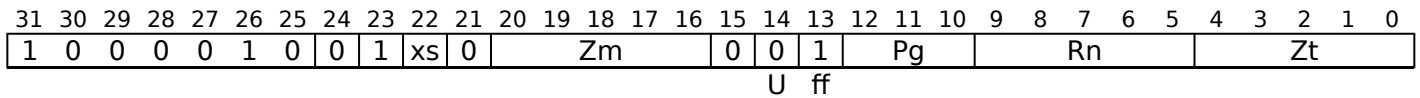
### 32-bit unpacked unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	1	xs	0	Zm					0	0	1	Pg			Rn					Zt				
msz<1>msz<0>										U ff																					

**LDFF1SH { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod>]**

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

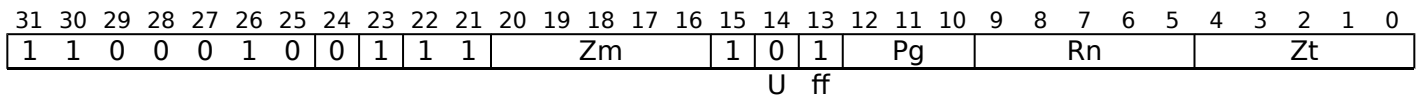
### 32-bit unscaled offset



**LDFF1SH { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod>]**

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

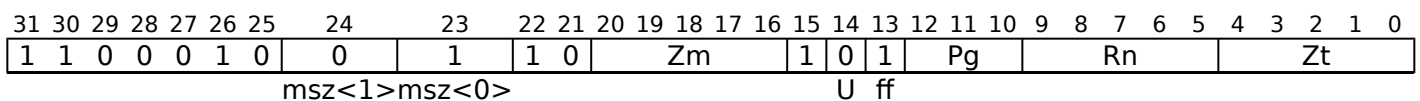
### 64-bit scaled offset



**LDFF1SH { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, LSL #1]**

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 64;
boolean unsigned = FALSE;
boolean offs_unsigned = TRUE;
integer scale = 1;
```

### 64-bit unscaled offset



LDFF1SH { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 64;
boolean unsigned = FALSE;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;
bits(VL) offset;
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = Z[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        bits(64) addr = base + (off << scale);
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

// FFR elements set to FALSE following a suppressed access/fault
faulted = faulted || fault;
if faulted then
    ElemFFR[e, esize] = '0';

// Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
unknown = unknown || ElemFFR[e, esize] == '0';
if unknown then
    if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
        Elem[result, e, esize] = Zeros();
    else // merge
        Elem[result, e, esize] = Elem[orig, e, esize];
else
    Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

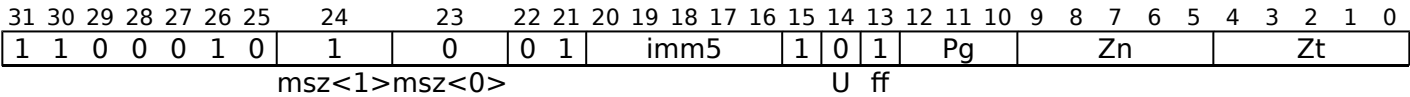
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDFF1SW (vector plus immediate)

Gather load first-fault signed words to vector (immediate index)

Gather load with first-faulting behavior of signed words to active elements of a vector register from memory addresses generated by a vector base plus immediate index. The index is a multiple of 4 in the range 0 to 124. Inactive elements will not cause a read from Device memory or signal faults, and are set to zero in the destination vector.



LDFF1SW { <Zt>.D }, <Pg>/Z, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
boolean unsigned = FALSE;
integer offset = UInt(imm5);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 4 in the range 0 to 124, defaulting to 0, encoded in the "imm5" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) base;
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if AnyActiveElement(mask, esize) then
    base = Z[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

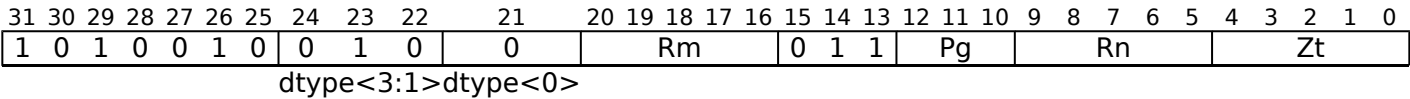
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDFF1SW (scalar plus scalar)

Contiguous load first-fault signed words to vector (scalar index)

Contiguous load with first-faulting behavior of signed words to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 4 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.



LDFF1SW { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, <Xm>, LSL #2}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
boolean unsigned = FALSE;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the optional 64-bit name of the general-purpose offset register, defaulting to XZR, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
bits(64) offset;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = X[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = base + (UInt(offset) + e) * mbytes;
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_NOTFIRST];
        else
            (data, fault) = (Zeros(msize), FALSE);

// FFR elements set to FALSE following a suppressed access/fault
faulted = faulted || fault;
if faulted then
    ElemFFR[e, esize] = '0';

// Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
unknown = unknown || ElemFFR[e, esize] == '0';
if unknown then
    if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
        Elem[result, e, esize] = Zeros();
    else // merge
        Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LDFF1SW (scalar plus vector)

Gather load first-fault signed words to vector (vector index)

Gather load with first-faulting behavior of signed words to active elements of a vector register from memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then optionally multiplied by 4. Inactive elements will not cause a read from Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 4 classes: [32-bit unpacked scaled offset](#) , [32-bit unpacked unscaled offset](#) , [64-bit scaled offset](#) and [64-bit unscaled offset](#)

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	1	0	xs	1	Zm					0	0	1	Pg			Rn					Zt				
																U				ff											

LDFF1SW { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod> #2]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 2;
```

### 32-bit unpacked unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	1	0	xs	0	Zm					0	0	1	Pg			Rn					Zt				
msz<1>msz<0>																U												ff			

LDFF1SW { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

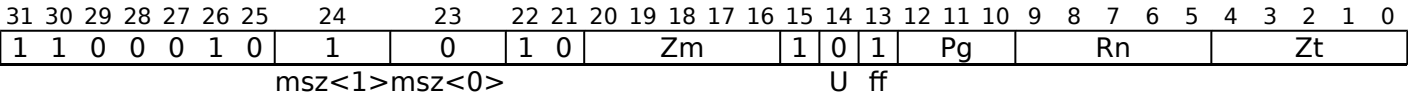
### 64-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	1	0	1	1	Zm					1	0	1	Pg			Rn					Zt				
																U				ff											

LDFF1SW { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, LSL #2]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 64;
boolean unsigned = FALSE;
boolean offs_unsigned = TRUE;
integer scale = 2;
```

64-bit unscaled offset



LDFF1SW { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 64;
boolean unsigned = FALSE;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;
bits(VL) offset;
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = Z[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        bits(64) addr = base + (off << scale);
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

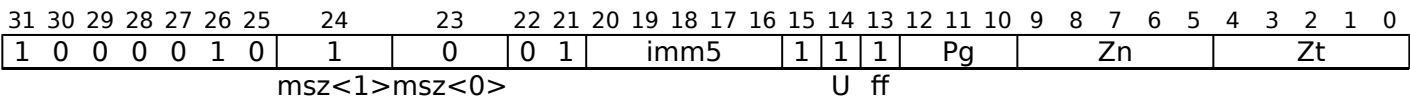
# LDFF1W (vector plus immediate)

Gather load first-fault unsigned words to vector (immediate index)

Gather load with first-faulting behavior of unsigned words to active elements of a vector register from memory addresses generated by a vector base plus immediate index. The index is a multiple of 4 in the range 0 to 124. Inactive elements will not cause a read from Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

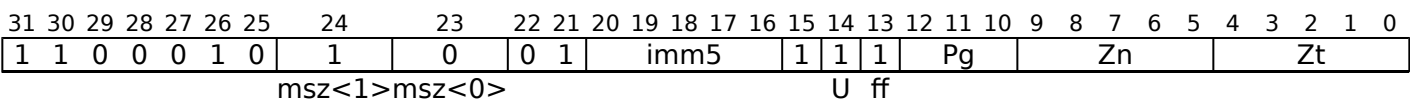
## 32-bit element



LDFF1W { <Zt>.S }, <Pg>/Z, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 32;
boolean unsigned = TRUE;
integer offset = UInt(imm5);
```

## 64-bit element



LDFF1W { <Zt>.D }, <Pg>/Z, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
boolean unsigned = TRUE;
integer offset = UInt(imm5);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 4 in the range 0 to 124, defaulting to 0, encoded in the "imm5" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) base;
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if AnyActiveElement(mask, esize) then
    base = Z[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



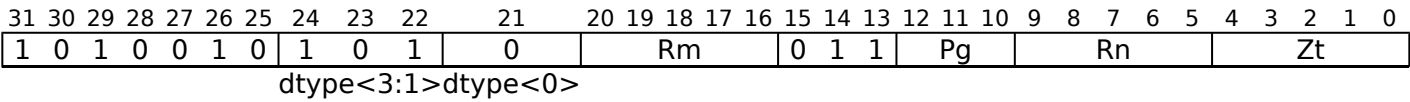
# LDFF1W (scalar plus scalar)

Contiguous load first-fault unsigned words to vector (scalar index)

Contiguous load with first-faulting behavior of unsigned words to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 4 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

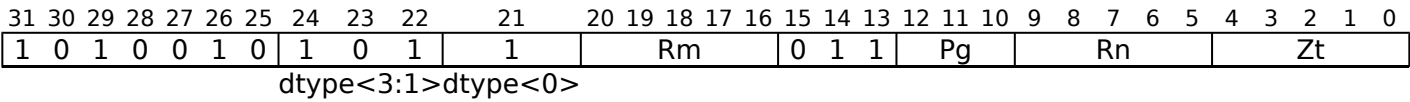
## 32-bit element



LDFF1W { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, <Xm>, LSL #2}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 32;
boolean unsigned = TRUE;
```

## 64-bit element



LDFF1W { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, <Xm>, LSL #2}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
boolean unsigned = TRUE;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the optional 64-bit name of the general-purpose offset register, defaulting to XZR, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
bits(64) offset;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = base + (UInt(offset) + e) * mbytes;
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_NOTFIRST];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LDFF1W (scalar plus vector)

Gather load first-fault unsigned words to vector (vector index)

Gather load with first-faulting behavior of unsigned words to active elements of a vector register from memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then optionally multiplied by 4. Inactive elements will not cause a read from Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 6 classes: [32-bit scaled offset](#) , [32-bit unpacked scaled offset](#) , [32-bit unpacked unscaled offset](#) , [32-bit unscaled offset](#) , [64-bit scaled offset](#) and [64-bit unscaled offset](#)

### 32-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	1	0	xs	1	Zm					0	1	1	Pg			Rn					Zt				
																U ff															

LDFF1W { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod> #2]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 32;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 2;
```

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	1	0	xs	1	Zm					0	1	1	Pg			Rn					Zt				
U ff																															

LDFF1W { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod> #2]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 2;
```

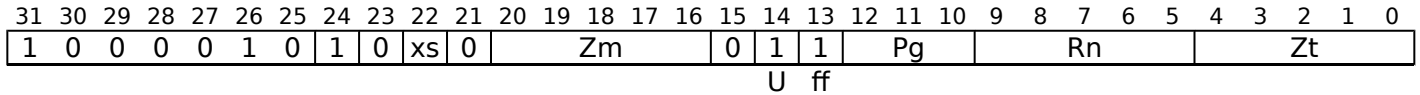
### 32-bit unpacked unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	1	0	xs	0	Zm					0	1	1	Pg			Rn					Zt				
msz<1>msz<0>																U ff															

LDFF1W { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

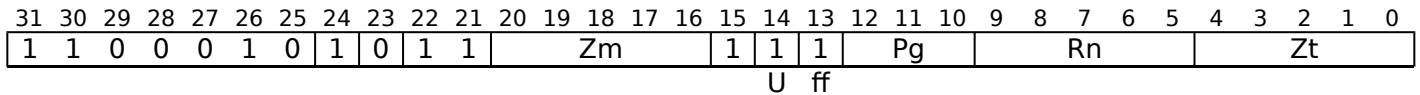
### 32-bit unscaled offset



LDFF1W { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 32;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

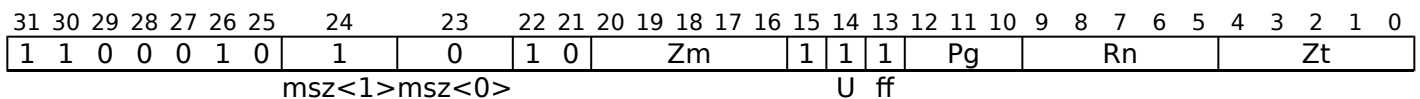
### 64-bit scaled offset



LDFF1W { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, LSL #2]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 64;
boolean unsigned = TRUE;
boolean offs_unsigned = TRUE;
integer scale = 2;
```

### 64-bit unscaled offset



LDFF1W { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 64;
boolean unsigned = TRUE;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;
bits(VL) offset;
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = Z[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        bits(64) addr = base + (off << scale);
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LDNF1B

Contiguous load non-fault unsigned bytes to vector (immediate index)

Contiguous load with non-faulting behavior of unsigned bytes to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 4 classes: [8-bit element](#) , [16-bit element](#) , [32-bit element](#) and [64-bit element](#)

### 8-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	0	0	0	1	imm4				1	0	1	Pg			Rn				Zt					
dtype<3:1>dtype<0>																															

LDNF1B { <Zt>.B }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

### 16-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	0	0	1	1	imm4				1	0	1	Pg			Rn				Zt					
dtype<3:1>dtype<0>																															

LDNF1B { <Zt>.H }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

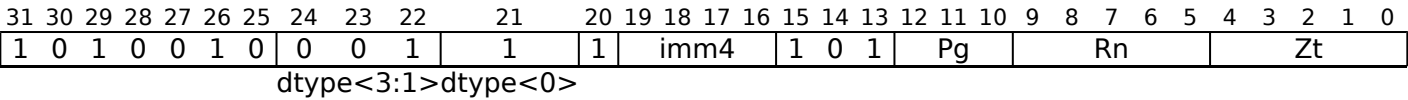
### 32-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	0	1	0	1	imm4				1	0	1	Pg			Rn				Zt					
dtype<3:1>dtype<0>																															

LDNF1B { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

64-bit element



```
LDNF1B { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + eoff * mbytes;
        // MemNF[] will return fault=TRUE if access is not performed for any reason
        (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

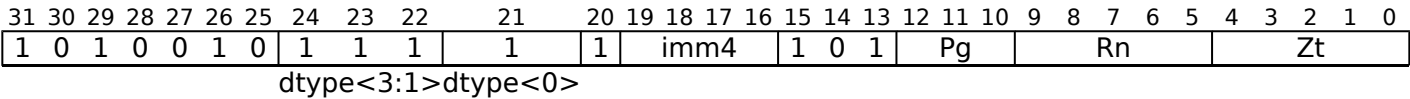
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

LDNF1D

Contiguous load non-fault doublewords to vector (immediate index)

Contiguous load with non-faulting behavior of doublewords to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.



```
LDNF1D { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + eoff * mbytes;
        // MemNF[] will return fault=TRUE if access is not performed for any reason
        (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LDNF1H

Contiguous load non-fault unsigned halfwords to vector (immediate index)

Contiguous load with non-faulting behavior of unsigned halfwords to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 3 classes: [16-bit element](#) , [32-bit element](#) and [64-bit element](#)

### 16-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	1	0	1	1	imm4				1	0	1	Pg			Rn				Zt					
dtype<3:1>dtype<0>																															

LDNF1H { <Zt>.H }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer msize = 16;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

### 32-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	1	1	0	1	imm4				1	0	1	Pg			Rn				Zt					
dtype<3:1>dtype<0>																															

LDNF1H { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

### 64-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	1	1	1	1	imm4				1	0	1	Pg			Rn				Zt					
dtype<3:1>dtype<0>																															

LDNF1H { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

## Assembler Symbols

<Zt>	Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<imm>	Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + eoff * mbytes;
        // MemNF[] will return fault=TRUE if access is not performed for any reason
        (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LDNF1SB

Contiguous load non-fault signed bytes to vector (immediate index)

Contiguous load with non-faulting behavior of signed bytes to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 3 classes: [16-bit element](#) , [32-bit element](#) and [64-bit element](#)

### 16-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	1	1	1	0	1	imm4				1	0	1	Pg			Rn				Zt					
dtype<3:1>dtype<0>																															

LDNF1SB { <Zt>.H }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer msize = 8;
boolean unsigned = FALSE;
integer offset = SInt(imm4);
```

### 32-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	1	1	0	1	1	imm4				1	0	1	Pg			Rn				Zt					
dtype<3:1>dtype<0>																															

LDNF1SB { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
boolean unsigned = FALSE;
integer offset = SInt(imm4);
```

### 64-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	1	1	0	0	1	imm4				1	0	1	Pg			Rn				Zt					
dtype<3:1>dtype<0>																															

LDNF1SB { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
boolean unsigned = FALSE;
integer offset = SInt(imm4);
```

## Assembler Symbols

<Zt>	Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<imm>	Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + eoff * mbytes;
        // MemNF[] will return fault=TRUE if access is not performed for any reason
        (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDNF1SH

Contiguous load non-fault signed halfwords to vector (immediate index)

Contiguous load with non-faulting behavior of signed halfwords to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

## 32-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	1	0	0	1	1	imm4				1	0	1	Pg			Rn				Zt					
dtype<3:1>dtype<0>																															

LDNF1SH { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
boolean unsigned = FALSE;
integer offset = SInt(imm4);
```

## 64-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	1	0	0	0	1	imm4				1	0	1	Pg			Rn				Zt					
dtype<3:1>dtype<0>																															

LDNF1SH { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
boolean unsigned = FALSE;
integer offset = SInt(imm4);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + eoff * mbytes;
        // MemNF[] will return fault=TRUE if access is not performed for any reason
        (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

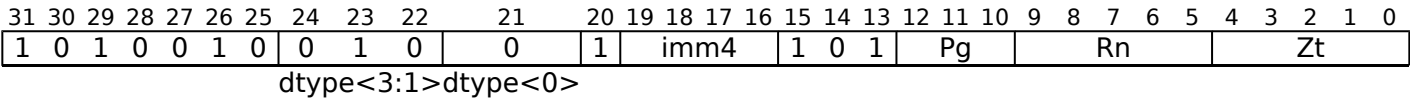
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LDNF1SW

Contiguous load non-fault signed words to vector (immediate index)

Contiguous load with non-faulting behavior of signed words to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.



LDNF1SW { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
boolean unsigned = FALSE;
integer offset = SInt(imm4);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + eoff * mbytes;
        // MemNF[] will return fault=TRUE if access is not performed for any reason
        (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

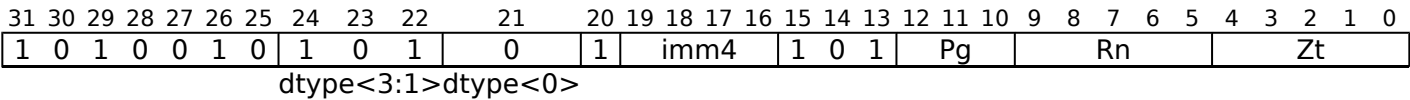
# LDNF1W

Contiguous load non-fault unsigned words to vector (immediate index)

Contiguous load with non-faulting behavior of unsigned words to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

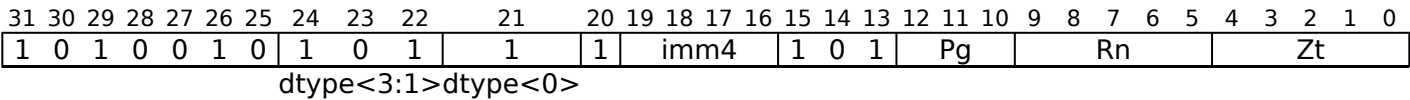
## 32-bit element



LDNF1W { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 32;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

## 64-bit element



LDNF1W { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + eoff * mbytes;
        // MemNF[] will return fault=TRUE if access is not performed for any reason
        (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

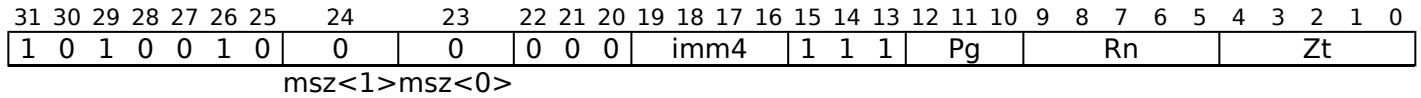
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## LDNT1B (scalar plus immediate)

Contiguous load non-temporal bytes to vector (immediate index)

Contiguous load non-temporal of bytes to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.

A non-temporal load is a hint to the system that this data is unlikely to be referenced again soon.



LDNT1B { <Zt>.B }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8;
integer offset = SInt(imm4);
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + eoff * mbytes;
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_STREAM];
    else
        Elem[result, e, esize] = Zeros();

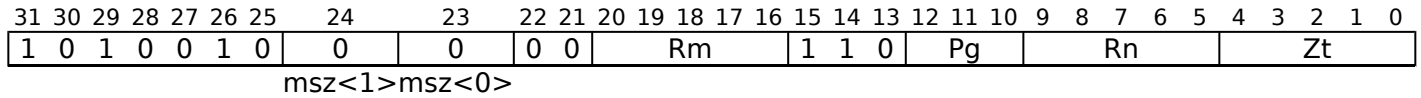
Z[t] = result;
```

## LDNT1B (scalar plus scalar)

Contiguous load non-temporal bytes to vector (scalar index)

Contiguous load non-temporal of bytes to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.

A non-temporal load is a hint to the system that this data is unlikely to be referenced again soon.



**LDNT1B { <Zt>.B }, <Pg>/Z, [<Xn|SP>, <Xm>]**

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 8;
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) offset;
bits(PL) mask = P[g];
bits(VL) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = X[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = base + (UInt(offset) + e) * mbytes;
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_STREAM];
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```



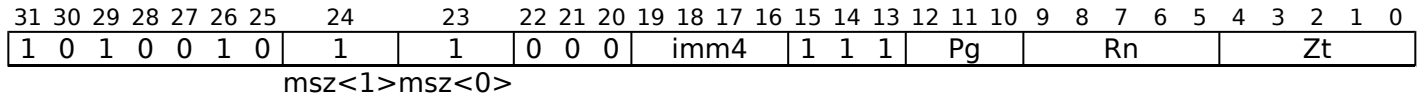


## LDNT1D (scalar plus immediate)

Contiguous load non-temporal doublewords to vector (immediate index)

Contiguous load non-temporal of doublewords to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.

A non-temporal load is a hint to the system that this data is unlikely to be referenced again soon.



LDNT1D { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer offset = SInt(imm4);
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + eoff * mbytes;
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_STREAM];
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

## LDNT1D (scalar plus scalar)

Contiguous load non-temporal doublewords to vector (scalar index)

Contiguous load non-temporal of doublewords to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 8 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.

A non-temporal load is a hint to the system that this data is unlikely to be referenced again soon.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	1	1	0	0	Rm			1	1	0	Pg		Rn			Zt									
msz<1>msz<0>																															

LDNT1D { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #3]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
```

### Assembler Symbols

<Zt>	Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) offset;
bits(PL) mask = P[g];
bits(VL) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = X[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = base + (UInt(offset) + e) * mbytes;
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_STREAM];
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

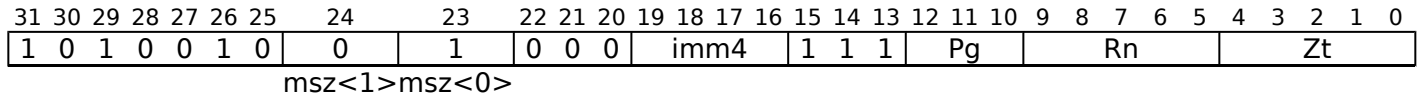


## LDNT1H (scalar plus immediate)

Contiguous load non-temporal halfwords to vector (immediate index)

Contiguous load non-temporal of halfwords to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.

A non-temporal load is a hint to the system that this data is unlikely to be referenced again soon.



LDNT1H { <Zt>.H }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer offset = SInt(imm4);
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + eoff * mbytes;
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_STREAM];
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

## LDNT1H (scalar plus scalar)

Contiguous load non-temporal halfwords to vector (scalar index)

Contiguous load non-temporal of halfwords to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 2 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.

A non-temporal load is a hint to the system that this data is unlikely to be referenced again soon.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	1	0	0		Rm				1	1	0		Pg			Rn				Zt				
							msz<1>		msz<0>																						

LDNT1H { <Zt>.H }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
```

### Assembler Symbols

<Zt>	Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) offset;
bits(PL) mask = P[g];
bits(VL) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = X[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = base + (UInt(offset) + e) * mbytes;
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_STREAM];
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

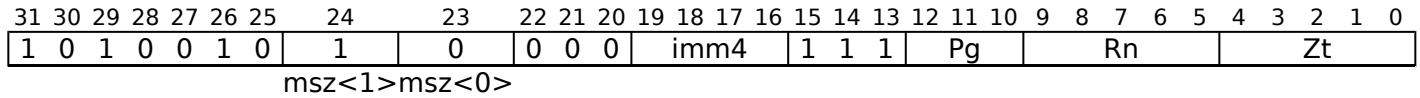


## LDNT1W (scalar plus immediate)

Contiguous load non-temporal words to vector (immediate index)

Contiguous load non-temporal of words to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.

A non-temporal load is a hint to the system that this data is unlikely to be referenced again soon.



LDNT1W { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer offset = SInt(imm4);
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + eoff * mbytes;
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_STREAM];
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

## LDNT1W (scalar plus scalar)

Contiguous load non-temporal words to vector (scalar index)

Contiguous load non-temporal of words to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 4 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not cause a read from Device memory or signal a fault, and are set to zero in the destination vector.

A non-temporal load is a hint to the system that this data is unlikely to be referenced again soon.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	1	0	0	0	Rm			1	1	0	Pg			Rn			Zt								
							msz<1>		msz<0>																						

LDNT1W { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #2]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
```

### Assembler Symbols

<Zt>	Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) offset;
bits(PL) mask = P[g];
bits(VL) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = X[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = base + (UInt(offset) + e) * mbytes;
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_STREAM];
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```





# LDR (predicate)

Load predicate register

Load a predicate register from a memory address generated by a 64-bit scalar base, plus an immediate offset in the range -256 to 255 which is multiplied by the current predicate register size in bytes. This instruction is unpredicated. The load is performed as a stream of bytes containing 8 consecutive predicate bits in ascending element order, without any endian conversion.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	1	1	0	imm9h						0	0	0	imm9l			Rn			0	Pt					

LDR <Pt>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Pt);
integer n = UInt(Rn);
integer imm = SInt(imm9h:imm9l);
```

## Assembler Symbols

- <Pt> Is the name of the destination scalable predicate register, encoded in the "Pt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -256 to 255, defaulting to 0, encoded in the "imm9h:imm9l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = PL DIV 8;
bits(64) base;
integer offset = imm * elements;
bits(PL) result;

if n == 31 then
    CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

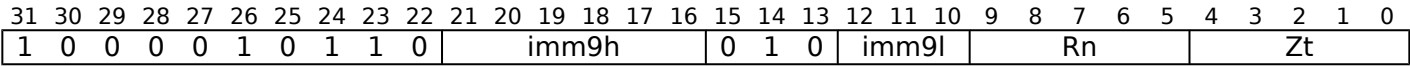
boolean aligned = AArch64.CheckAlignment(base + offset, 2, AccType_NORMAL, FALSE);
for e = 0 to elements-1
    Elem[result, e, 8] = AArch64.MemSingle(base + offset, 1, AccType_NORMAL, aligned);
    offset = offset + 1;

P[t] = result;
```

# LDR (vector)

Load vector register

Load a vector register from a memory address generated by a 64-bit scalar base, plus an immediate offset in the range -256 to 255 which is multiplied by the current vector register size in bytes. This instruction is unpredicated. The load is performed as a stream of byte elements in ascending element order, without any endian conversion.



LDR <Zt>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer imm = SInt(imm9h:imm9l);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -256 to 255, defaulting to 0, encoded in the "imm9h:imm9l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV 8;
bits(64) base;
integer offset = imm * elements;
bits(VL) result;

if n == 31 then
    CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

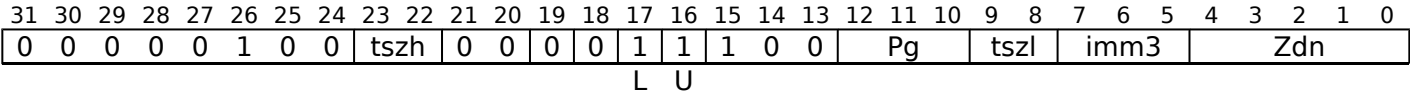
boolean aligned = AArch64.CheckAlignment(base + offset, 16, AccType_NORMAL, FALSE);
for e = 0 to elements-1
    Elem[result, e, 8] = AArch64.MemSingle(base + offset, 1, AccType_NORMAL, aligned);
    offset = offset + 1;

Z[t] = result;
```

# LSL (immediate, predicated)

Logical shift left by immediate (predicated)

Shift left by immediate each active element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate shift amount is an unsigned value in the range 0 to number of bits per element minus 1. Inactive elements in the destination vector register remain unmodified.



LSL <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, #<const>

```
if !HaveSVE() then UNDEFINED;
bits(4) tsize = tszh:tszl;
case tsize of
    when '0000' UNDEFINED;
    when '0001' esize = 8;
    when '001x' esize = 16;
    when '01xx' esize = 32;
    when '1xxx' esize = 64;
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer shift = UInt(tsize:imm3) - esize;
```

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
00	00	RESERVED
00	01	B
00	1x	H
01	xx	S
1x	xx	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<const> Is the immediate shift amount, in the range 0 to number of bits per element minus 1, encoded in "tsz:imm3".

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(PL) mask = P[g];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = LSL(element1, shift);
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];
Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

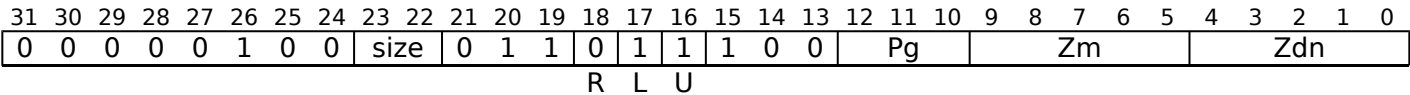
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LSL (wide elements, predicated)

Logical shift left by 64-bit wide elements (predicated)

Shift left active elements of the first source vector by corresponding overlapping 64-bit elements of the second source vector and destructively place the results in the corresponding elements of the first source vector. The shift amount is a vector of unsigned 64-bit doubleword elements in which all bits are significant, and not used modulo the destination element size. Inactive elements in the destination vector register remain unmodified.



LSL <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<D>

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	RESERVED

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(64) element2 = Elem[operand2, (e * esize) DIV 64, 64];
    integer shift = Min(UInt(element2), esize);
    Elem[result, e, esize] = LSL(element1, shift);
  else
    Elem[result, e, esize] = Elem[operand1, e, esize];
Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and destination element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

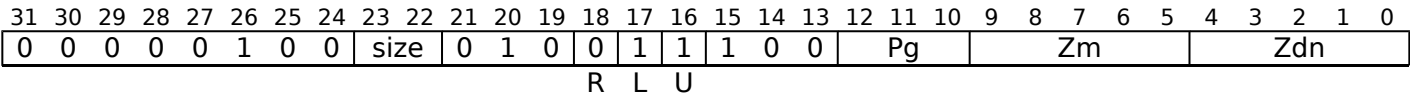
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LSL (vectors)

Logical shift left by vector (predicated)

Shift left active elements of the first source vector by corresponding elements of the second source vector and destructively place the results in the corresponding elements of the first source vector. The shift amount operand is a vector of unsigned elements in which all bits are significant, and not used modulo the element size. Inactive elements in the destination vector register remain unmodified.



LSL <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element1 = Elem[operand1, e, esize];
        bits(esize) element2 = Elem[operand2, e, esize];
        integer shift = Min(UInt(element2), esize);
        Elem[result, e, esize] = LSL(element1, shift);
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:



- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

LSL (immediate, unpredicated)

Logical shift left by immediate (unpredicated)

Shift left by immediate each element of the source vector, and place the results in the corresponding elements of the destination vector. The immediate shift amount is an unsigned value in the range 0 to number of bits per element minus 1. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	tszh	1	tszl	imm3	1	0	0	1	1	1														

LSL <Zd>.<T>, <Zn>.<T>, #<const>

```
if !HaveSVE() then UNDEFINED;
bits(4) tsize = tszh:tszl;
case tsize of
    when '0000' UNDEFINED;
    when '0001' esize = 8;
    when '001x' esize = 16;
    when '01xx' esize = 32;
    when '1xxx' esize = 64;
integer n = UInt(Zn);
integer d = UInt(Zd);
integer shift = UInt(tsize:imm3) - esize;
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
00	00	RESERVED
00	01	B
00	1x	H
01	xx	S
1x	xx	D

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<const> Is the immediate shift amount, in the range 0 to number of bits per element minus 1, encoded in "tsz:imm3".

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    Elem[result, e, esize] = LSL(element1, shift);

Z[d] = result;
```

LSL (wide elements, unpredicated)

Logical shift left by 64-bit wide elements (unpredicated)

Shift left all elements of the first source vector by corresponding overlapping 64-bit elements of the second source vector and place the first in the corresponding elements of the destination vector. The shift amount is a vector of unsigned 64-bit doubleword elements in which all bits are significant, and not used modulo the destination element size. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1	Zm						1	0	0	0	1	1	Zn						Zd			

LSL <Zd>.<T>, <Zn>.<T>, <Zm>.D

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	RESERVED

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

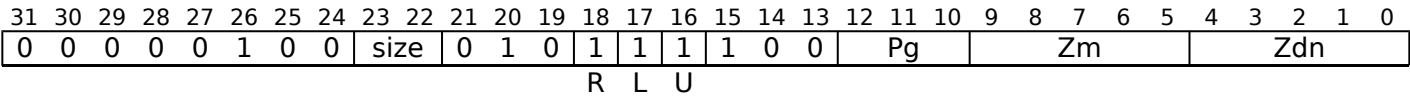
for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(64) element2 = Elem[operand2, (e * esize) DIV 64, 64];
    integer shift = Min(UInt(element2), esize);
    Elem[result, e, esize] = LSL(element1, shift);

Z[d] = result;
```

LSLR

Reversed logical shift left by vector (predicated)

Reversed shift left active elements of the second source vector by corresponding elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. The shift amount operand is a vector of unsigned elements in which all bits are significant, and not used modulo the element size. Inactive elements in the destination vector register remain unmodified.



LSLR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    integer shift = Min(UInt(element1), esize);
    Elem[result, e, esize] = LSL(element2, shift);
  else
    Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

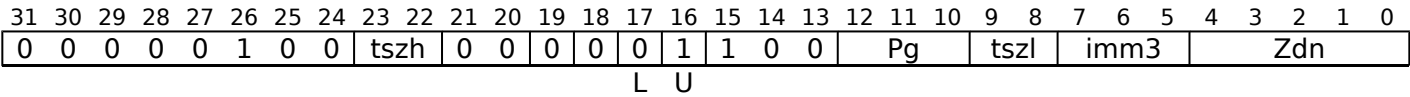
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LSR (immediate, predicated)

Logical shift right by immediate (predicated)

Shift right by immediate, inserting zeroes, each active element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate shift amount is an unsigned value in the range 1 to number of bits per element. Inactive elements in the destination vector register remain unmodified.



LSR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, #<const>

```
if !HaveSVE() then UNDEFINED;
bits(4) tsize = tszh:tszl;
case tsize of
    when '0000' UNDEFINED;
    when '0001' esize = 8;
    when '001x' esize = 16;
    when '01xx' esize = 32;
    when '1xxx' esize = 64;
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
00	00	RESERVED
00	01	B
00	1x	H
01	xx	S
1x	xx	D
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <const> Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(PL) mask = P[g];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = LSR(element1, shift);
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];
Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

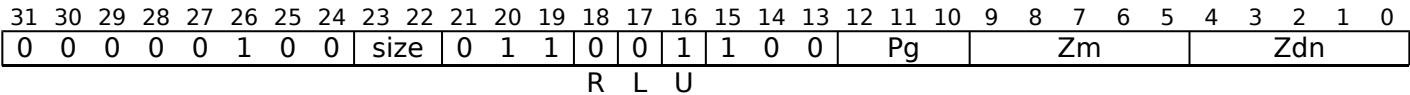
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# LSR (wide elements, predicated)

Logical shift right by 64-bit wide elements (predicated)

Shift right, inserting zeroes, active elements of the first source vector by corresponding overlapping 64-bit elements of the second source vector and destructively place the results in the corresponding elements of the first source vector. The shift amount is a vector of unsigned 64-bit doubleword elements in which all bits are significant, and not used modulo the destination element size. Inactive elements in the destination vector register remain unmodified.



LSR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<D>

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	RESERVED

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element1 = Elem[operand1, e, esize];
        bits(64) element2 = Elem[operand2, (e * esize) DIV 64, 64];
        integer shift = Min(UInt(element2), esize);
        Elem[result, e, esize] = LSR(element1, shift);
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];
Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:



- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and destination element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

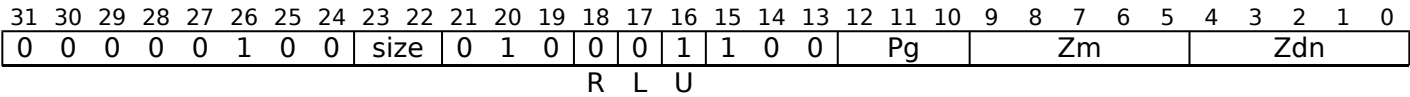
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

LSR (vectors)

Logical shift right by vector (predicated)

Shift right, inserting zeroes, active elements of the first source vector by corresponding elements of the second source vector and destructively place the results in the corresponding elements of the first source vector. The shift amount operand is a vector of unsigned elements in which all bits are significant, and not used modulo the element size. Inactive elements in the destination vector register remain unmodified.



LSR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element1 = Elem[operand1, e, esize];
        bits(esize) element2 = Elem[operand2, e, esize];
        integer shift = Min(UInt(element2), esize);
        Elem[result, e, esize] = LSR(element1, shift);
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

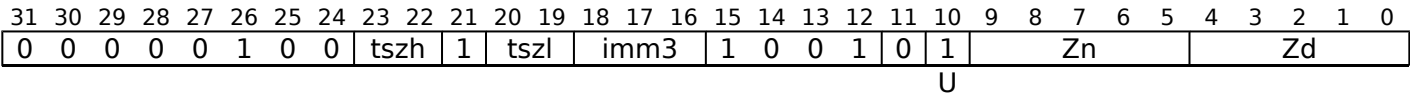
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

LSR (immediate, unpredicated)

Logical shift right by immediate (unpredicated)

Shift right by immediate, inserting zeroes, each element of the source vector, and place the results in the corresponding elements of the destination vector. The immediate shift amount is an unsigned value in the range 1 to number of bits per element. This instruction is unpredicated.



LSR <Zd>.<T>, <Zn>.<T>, #<const>

```
if !HaveSVE() then UNDEFINED;
bits(4) tsize = tszh:tszl;
case tsize of
  when '0000' UNDEFINED;
  when '0001' esize = 8;
  when '001x' esize = 16;
  when '01xx' esize = 32;
  when '1xxx' esize = 64;
integer n = UInt(Zn);
integer d = UInt(Zd);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
00	00	RESERVED
00	01	B
00	1x	H
01	xx	S
1x	xx	D

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<const> Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) result;

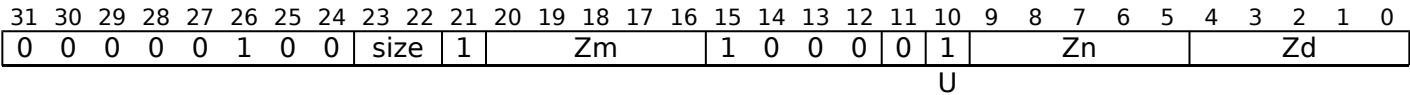
for e = 0 to elements-1
  bits(esize) element1 = Elem[operand1, e, esize];
  Elem[result, e, esize] = LSR(element1, shift);

Z[d] = result;
```

LSR (wide elements, unpredicated)

Logical shift right by 64-bit wide elements (unpredicated)

Shift right, inserting zeroes, all elements of the first source vector by corresponding overlapping 64-bit elements of the second source vector and place the first in the corresponding elements of the destination vector. The shift amount is a vector of unsigned 64-bit doubleword elements in which all bits are significant, and not used modulo the destination element size. This instruction is unpredicated.



LSR <Zd>.<T>, <Zn>.<T>, <Zm>.<D>

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	RESERVED

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

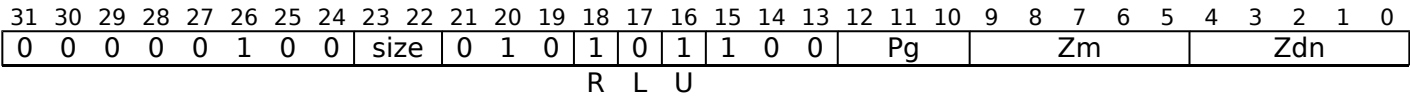
for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(64) element2 = Elem[operand2, (e * esize) DIV 64, 64];
    integer shift = Min(UInt(element2), esize);
    Elem[result, e, esize] = LSR(element1, shift);

Z[d] = result;
```

# LSRR

Reversed logical shift right by vector (predicated)

Reversed shift right, inserting zeroes, active elements of the second source vector by corresponding elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. The shift amount operand is a vector of unsigned elements in which all bits are significant, and not used modulo the element size. Inactive elements in the destination vector register remain unmodified.



LSRR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    integer shift = Min(UInt(element1), esize);
    Elem[result, e, esize] = LSR(element2, shift);
  else
    Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

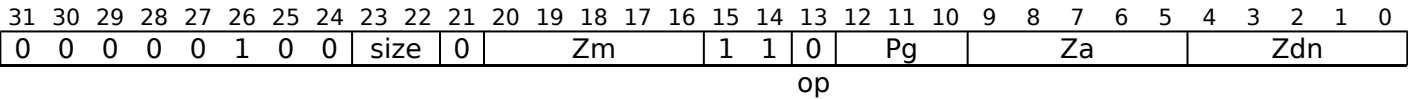
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

MAD

Multiply-add vectors (predicated), writing multiplicand [ $Zdn = Za + Zdn * Zm$ ]

Multiply the corresponding active elements of the first and second source vectors and add to elements of the third (addend) vector. Destructively place the results in the destination and first source (multiplicand) vector. Inactive elements in the destination vector register remain unmodified.



MAD <Zdn>.<T>, <Pg>/M, <Zm>.<T>, <Za>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
integer a = UInt(Za);
boolean sub_op = FALSE;
```

Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <Za> Is the name of the third source scalable vector register, encoded in the "Za" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) operand3 = if AnyActiveElement(mask, esize) then Z[a] else Zeros();
bits(VL) result;

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, e, esize]);
    integer product = element1 * element2;
    if sub_op then
      Elem[result, e, esize] = Elem[operand3, e, esize] - product;
    else
      Elem[result, e, esize] = Elem[operand3, e, esize] + product;
  else
    Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```



## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

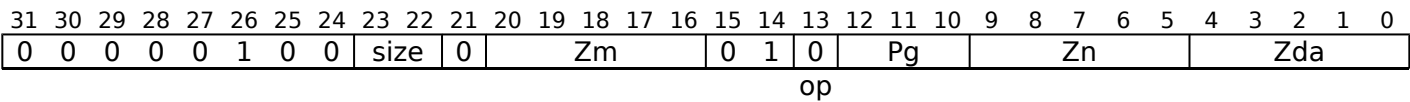
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

MLA

Multiply-add vectors (predicated), writing addend [ $Zda = Zda + Zn * Zm$ ]

Multiply the corresponding active elements of the first and second source vectors and add to elements of the third source (addend) vector. Destructively place the results in the destination and third source (addend) vector. Inactive elements in the destination vector register remain unmodified.



```
MLA <Zda>.<T>, <Pg>/M, <Zn>.<T>, <Zm>.<T>
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean sub_op = FALSE;
```

Assembler Symbols

<Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, e, esize]);
    integer product = element1 * element2;
    if sub_op then
      Elem[result, e, esize] = Elem[operand3, e, esize] - product;
    else
      Elem[result, e, esize] = Elem[operand3, e, esize] + product;
  else
    Elem[result, e, esize] = Elem[operand3, e, esize];

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

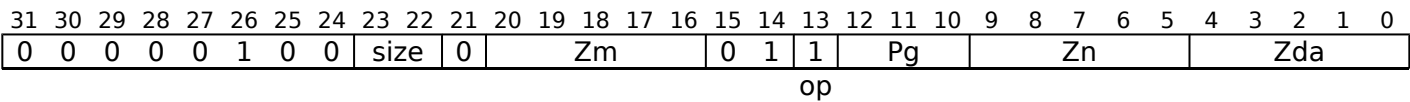
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

MLS

Multiply-subtract vectors (predicated), writing addend [Zda = Zda - Zn \* Zm]

Multiply the corresponding active elements of the first and second source vectors and subtract from elements of the third source (addend) vector. Destructively place the results in the destination and third source (addend) vector. Inactive elements in the destination vector register remain unmodified.



```
MLS <Zda>.<T>, <Pg>/M, <Zn>.<T>, <Zm>.<T>
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean sub_op = TRUE;
```

Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, e, esize]);
    integer product = element1 * element2;
    if sub_op then
      Elem[result, e, esize] = Elem[operand3, e, esize] - product;
    else
      Elem[result, e, esize] = Elem[operand3, e, esize] + product;
  else
    Elem[result, e, esize] = Elem[operand3, e, esize];

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# MOV (predicate, predicated, zeroing)

Move predicates (zeroing)

Read active elements from the source predicate and place in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Does not set the condition flags.

This is an alias of [AND, ANDS \(predicates\)](#). This means:

- The encodings in this description are named to match the encodings of [AND, ANDS \(predicates\)](#).
- The description of [AND, ANDS \(predicates\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	0	0	0	Pm				0	1	Pg				0	Pn				0	Pd			
S																															

MOV <Pd>.B, <Pg>/Z, <Pn>.B

is equivalent to

AND <Pd>.B, <Pg>/Z, <Pn>.B, <Pn>.B

and is the preferred disassembly when S == '0' && Pn == Pm.

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.

## Operation

The description of [AND, ANDS \(predicates\)](#) gives the operational pseudocode for this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# MOV (immediate, predicated, zeroing)

Move signed integer immediate to vector elements (zeroing)

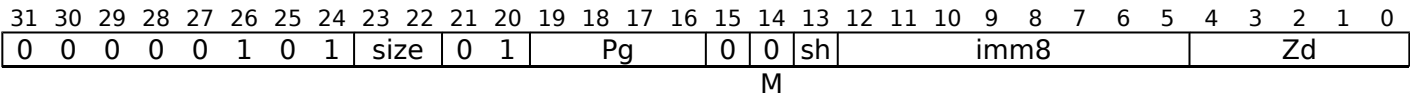
Move a signed integer immediate to each active element in the destination vector. Inactive elements in the destination vector register are set to zero.

The immediate operand is a signed value in the range -128 to +127, and for element widths of 16 bits or higher it may also be a signed multiple of 256 in the range -32768 to +32512 (excluding 0).

The immediate is encoded in 8 bits with an optional left shift by 8. The preferred disassembly when the shift option is specified is "#<imm8>, LSL #8". However an assembler and disassembler may also allow use of the shifted 16-bit value unless the immediate is 0 and the shift amount is 8, which must be unambiguously described as "#0, LSL #8".

This is an alias of [CPY \(immediate, zeroing\)](#). This means:

- The encodings in this description are named to match the encodings of [CPY \(immediate, zeroing\)](#).
- The description of [CPY \(immediate, zeroing\)](#) gives the operational pseudocode for this instruction.



MOV <Zd>.<T>, <Pg>/Z, #<imm>{, <shift>}

is equivalent to

CPY <Zd>.<T>, <Pg>/Z, #<imm>{, <shift>}

and is always the preferred disassembly.

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.

<imm> Is a signed immediate in the range -128 to 127, encoded in the "imm8" field.

<shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #8

## Operation

The description of [CPY \(immediate, zeroing\)](#) gives the operational pseudocode for this instruction.

# MOV (immediate, predicated, merging)

Move signed integer immediate to vector elements (merging)

Move a signed integer immediate to each active element in the destination vector. Inactive elements in the destination vector register remain unmodified.

The immediate operand is a signed value in the range -128 to +127, and for element widths of 16 bits or higher it may also be a signed multiple of 256 in the range -32768 to +32512 (excluding 0).

The immediate is encoded in 8 bits with an optional left shift by 8. The preferred disassembly when the shift option is specified is "#<imm8>, LSL #8". However an assembler and disassembler may also allow use of the shifted 16-bit value unless the immediate is 0 and the shift amount is 8, which must be unambiguously described as "#0, LSL #8".

This is an alias of [CPY \(immediate, merging\)](#). This means:

- The encodings in this description are named to match the encodings of [CPY \(immediate, merging\)](#).
- The description of [CPY \(immediate, merging\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size		0	1	Pg			0	1	sh	imm8								Zd					
M																															

MOV <Zd>.<T>, <Pg>/M, #<imm>{, <shift>}

is equivalent to

CPY <Zd>.<T>, <Pg>/M, #<imm>{, <shift>}

and is always the preferred disassembly.

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.

<imm> Is a signed immediate in the range -128 to 127, encoded in the "imm8" field.

<shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #8

## Operation

The description of [CPY \(immediate, merging\)](#) gives the operational pseudocode for this instruction.

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.



- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# MOV (scalar, predicated)

Move general-purpose register to vector elements (predicated)

Move the general-purpose scalar source register to each active element in the destination vector. Inactive elements in the destination vector register remain unmodified.

This is an alias of [CPY \(scalar\)](#). This means:

- The encodings in this description are named to match the encodings of [CPY \(scalar\)](#).
- The description of [CPY \(scalar\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	1	0	0	0	1	0	1	Pg			Rn				Zd						

MOV <Zd>.<T>, <Pg>/M, <R><n|SP>

is equivalent to

CPY <Zd>.<T>, <Pg>/M, <R><n|SP>

and is always the preferred disassembly.

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<R> Is a width specifier, encoded in "size":

size	<R>
01	W
x0	W
11	X

<n|SP> Is the number [0-30] of the general-purpose source register or the name SP (31), encoded in the "Rn" field.

## Operation

The description of [CPY \(scalar\)](#) gives the operational pseudocode for this instruction.

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



# MOV (SIMD&FP scalar, predicated)

Move SIMD&FP scalar register to vector elements (predicated)

Move the SIMD & floating-point scalar source register to each active element in the destination vector. Inactive elements in the destination vector register remain unmodified.

This is an alias of [CPY \(SIMD&FP scalar\)](#). This means:

- The encodings in this description are named to match the encodings of [CPY \(SIMD&FP scalar\)](#).
- The description of [CPY \(SIMD&FP scalar\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size		1	0	0	0	0	0	1	0	0	Pg			Vn			Zd						

MOV <Zd>.<T>, <Pg>/M, <V><n>

is equivalent to

CPY <Zd>.<T>, <Pg>/M, <V><n>

and is always the preferred disassembly.

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<V> Is a width specifier, encoded in "size":

size	<V>
00	B
01	H
10	S
11	D

<n> Is the number [0-31] of the source SIMD&FP register, encoded in the "Vn" field.

## Operation

The description of [CPY \(SIMD&FP scalar\)](#) gives the operational pseudocode for this instruction.

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



# MOV (immediate, unpredicated)

Move signed immediate to vector elements (unpredicated)

Unconditionally broadcast the signed integer immediate into each element of the destination vector. This instruction is unpredicated.

The immediate operand is a signed value in the range -128 to +127, and for element widths of 16 bits or higher it may also be a signed multiple of 256 in the range -32768 to +32512 (excluding 0).

The immediate is encoded in 8 bits with an optional left shift by 8. The preferred disassembly when the shift option is specified is "#<simm8>, LSL #8". However an assembler and disassembler may also allow use of the shifted 16-bit value unless the immediate is 0 and the shift amount is 8, which must be unambiguously described as "#0, LSL #8".

This is an alias of [DUP \(immediate\)](#). This means:

- The encodings in this description are named to match the encodings of [DUP \(immediate\)](#).
- The description of [DUP \(immediate\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	1	1	0	0	0	1	1	sh	imm8								Zd					

MOV <Zd>.<T>, #<imm>{, <shift>}

is equivalent to

DUP <Zd>.<T>, #<imm>{, <shift>}

and is always the preferred disassembly.

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<imm> Is a signed immediate in the range -128 to 127, encoded in the "imm8" field.

<shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #8

## Operation

The description of [DUP \(immediate\)](#) gives the operational pseudocode for this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# MOV (scalar, unpredicated)

Move general-purpose register to vector elements (unpredicated)

Unconditionally broadcast the general-purpose scalar source register into each element of the destination vector. This instruction is unpredicated.

This is an alias of [DUP \(scalar\)](#). This means:

- The encodings in this description are named to match the encodings of [DUP \(scalar\)](#).
- The description of [DUP \(scalar\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size		1	0	0	0	0	0	0	0	1	1	1	0	Rn					Zd				

MOV <Zd>.<T>, <R><n|SP>

is equivalent to

[DUP](#) <Zd>.<T>, <R><n|SP>

and is always the preferred disassembly.

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<R> Is a width specifier, encoded in "size":

size	<R>
01	W
x0	W
11	X

<n|SP> Is the number [0-30] of the general-purpose source register or the name SP (31), encoded in the "Rn" field.

## Operation

The description of [DUP \(scalar\)](#) gives the operational pseudocode for this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# MOV (SIMD&FP scalar, unpredicated)

Move indexed element or SIMD&FP scalar to vector (unpredicated)

Unconditionally broadcast the SIMD&FP scalar into each element of the destination vector. This instruction is unpredicated.

This is an alias of [DUP \(indexed\)](#). This means:

- The encodings in this description are named to match the encodings of [DUP \(indexed\)](#).
- The description of [DUP \(indexed\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	imm2	1	tsz						0	0	1	0	0	0	Zn					Zd				

MOV <Zd>.<T>, <V><n>

is equivalent to

DUP <Zd>.<T>, <Zn>.<T>[0]

and is the preferred disassembly when BitCount(imm2:tsz) == 1.

MOV <Zd>.<T>, <Zn>.<T>[<imm>]

is equivalent to

DUP <Zd>.<T>, <Zn>.<T>[<imm>]

and is the preferred disassembly when BitCount(imm2:tsz) > 1.

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "tsz":

tsz	<T>
00000	RESERVED
xxxx1	B
xxx10	H
xx100	S
x1000	D
10000	Q

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<imm> Is the immediate index, in the range 0 to one less than the number of elements in 512 bits, encoded in "imm2:tsz".

<V> Is a width specifier, encoded in "tsz":

tsz	<V>
00000	RESERVED
xxxx1	B
xxx10	H
xx100	S
x1000	D
10000	Q

<n> Is the number [0-31] of the source SIMD&FP register, encoded in the "Zn" field.



## Operation

The description of [DUP \(indexed\)](#) gives the operational pseudocode for this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# MOV (bitmask immediate)

Move logical bitmask immediate to vector (unpredicated)

Unconditionally broadcast the logical bitmask immediate into each element of the destination vector. This instruction is unpredicated. The immediate is a 64-bit value consisting of a single run of ones or zeros repeating every 2, 4, 8, 16, 32 or 64 bits.

This is an alias of [DUPM](#). This means:

- The encodings in this description are named to match the encodings of [DUPM](#).
- The description of [DUPM](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	1	1	0	0	0	0	imm13														Zd			

MOV <Zd>.<T>, #<const>

is equivalent to

[DUPM](#) <Zd>.<T>, #<const>

and is the preferred disassembly when `SVEMoveMaskPreferred(imm13)`.

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "imm13<12>:imm13<5:0>":

imm13<12>	imm13<5:0>	<T>
0	0xxxxx	S
0	10xxxx	H
0	110xxx	B
0	1110xx	B
0	11110x	B
0	111110	RESERVED
0	111111	RESERVED
1	xxxxxx	D

<const> Is a 64, 32, 16 or 8-bit bitmask consisting of replicated 2, 4, 8, 16, 32 or 64 bit fields, each field containing a rotated run of non-zero bits, encoded in the "imm13" field.

## Operation

The description of [DUPM](#) gives the operational pseudocode for this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# MOV (predicate, unpredicated)

Move predicate (unpredicated)

Read all elements from the source predicate and place in the destination predicate. This instruction is unpredicated. Does not set the condition flags.

This is an alias of [ORR, ORRS \(predicates\)](#). This means:

- The encodings in this description are named to match the encodings of [ORR, ORRS \(predicates\)](#).
- The description of [ORR, ORRS \(predicates\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	1	0	0	0	Pm			0	1	Pg			0	Pn			0	Pd						
S																															

MOV <Pd>.B, <Pn>.B

is equivalent to

ORR <Pd>.B, <Pn>/Z, <Pn>.B, <Pn>.B

and is the preferred disassembly when S == '0' && Pn == Pm && Pm == Pg.

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.

## Operation

The description of [ORR, ORRS \(predicates\)](#) gives the operational pseudocode for this instruction.

# MOV (vector, unpredicated)

Move vector register (unpredicated)  
Move vector register. This instruction is unpredicated.

This is an alias of [ORR \(vectors, unpredicated\)](#). This means:

- The encodings in this description are named to match the encodings of [ORR \(vectors, unpredicated\)](#).
- The description of [ORR \(vectors, unpredicated\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1	Zm				0	0	1	1	0	0	Zn				Zd						

MOV <Zd>.D, <Zn>.D

is equivalent to

ORR <Zd>.D, <Zn>.D, <Zn>.D

and is the preferred disassembly when Zn == Zm.

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.  
<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

## Operation

The description of [ORR \(vectors, unpredicated\)](#) gives the operational pseudocode for this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41  
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# MOV (predicate, predicated, merging)

Move predicates (merging)

Read active elements from the source predicate and place in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register remain unmodified. Does not set the condition flags.

This is an alias of [SEL \(predicates\)](#). This means:

- The encodings in this description are named to match the encodings of [SEL \(predicates\)](#).
- The description of [SEL \(predicates\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	0	0	0	Pm				0	1	Pg				1	Pn				1	Pd			
S																															

MOV <Pd>.B, <Pg>/M, <Pn>.B

is equivalent to

SEL <Pd>.B, <Pg>, <Pn>.B, <Pd>.B

and is the preferred disassembly when Pd == Pm.

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.

## Operation

The description of [SEL \(predicates\)](#) gives the operational pseudocode for this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41  
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# MOV (vector, predicated)

Move vector elements (predicated)

Move elements from the source vector to the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

This is an alias of [SEL \(vectors\)](#). This means:

- The encodings in this description are named to match the encodings of [SEL \(vectors\)](#).
- The description of [SEL \(vectors\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	Zm			1	1	Pg			Zn			Zd										

MOV <Zd>.<T>, <Pg>/M, <Zn>.<T>

is equivalent to

SEL <Zd>.<T>, <Pg>, <Zn>.<T>, <Zd>.<T>

and is the preferred disassembly when **Zd == Zm**.

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

## Operation

The description of [SEL \(vectors\)](#) gives the operational pseudocode for this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# MOVPRFX (predicated)

Move prefix (predicated)

The predicated MOVPRFX instruction is a hint to hardware that the instruction may be combined with the destructive instruction which follows it in program order to create a single constructive operation. Since it is a hint it is also permitted to be implemented as a discrete vector copy, and the result of executing the pair of instructions with or without combining is identical. The choice of combined versus discrete operation may vary dynamically. Unless the combination of a constructive operation with merging predication is specifically required, it is strongly recommended that for performance reasons software should prefer to use the zeroing form of predicated MOVPRFX or the unpredicated MOVPRFX instruction.

Although the operation of the instruction is defined as a simple predicated vector copy, it is required that the prefixed instruction at PC+4 must be an SVE destructive binary or ternary instruction encoding, or a unary operation with merging predication, but excluding other MOVPRFX instructions. The prefixed instruction must specify the same predicate register, and have the same maximum element size (ignoring a fixed 64-bit "wide vector" operand), and the same destination vector as the MOVPRFX instruction. The prefixed instruction must not use the destination register in any other operand position, even if they have different names but refer to the same architectural register state. Any other use is UNPREDICTABLE.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	0	0	0	M	0	0	1	Pg				Zn				Zd					

MOVPRFX <Zd>.<T>, <Pg>/<ZM>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean merging = (M == '1');
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<ZM> Is the predication qualifier, encoded in "M":

M	<ZM>
0	Z
1	M

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) dest = Z[d];
bits(VL) result;

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element = Elem[operand1, e, esize];
        Elem[result, e, esize] = element;
    elseif merging then
        Elem[result, e, esize] = Elem[dest, e, esize];
    else
        Elem[result, e, esize] = Zeros();

Z[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# MOVPRFX (unpredicated)

Move prefix (unpredicated)

The unpredicated MOVPRFX instruction is a hint to hardware that the instruction may be combined with the destructive instruction which follows it in program order to create a single constructive operation. Since it is a hint it is also permitted to be implemented as a discrete vector copy, and the result of executing the pair of instructions with or without combining is identical. The choice of combined versus discrete operation may vary dynamically.

Although the operation of the instruction is defined as a simple unpredicated vector copy, it is required that the prefixed instruction at PC+4 must be an SVE destructive binary or ternary instruction encoding, or a unary operation with merging predication, but excluding other MOVPRFX instructions. The prefixed instruction must specify the same destination vector as the MOVPRFX instruction. The prefixed instruction must not use the destination register in any other operand position, even if they have different names but refer to the same architectural register state. Any other use is UNPREDICTABLE.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	1	1	1	1	Zn				Zd					

MOVPRFX <Zd>, <Zn>

```
if !HaveSVE() then UNDEFINED;
integer n = UInt(Zn);
integer d = UInt(Zd);
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
bits(VL) result = Z[n];
Z[d] = result;
```

# MOVS (predicated)

Move predicates (zeroing), setting the condition flags

Read active elements from the source predicate and place in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

This is an alias of [AND, ANDS \(predicates\)](#). This means:

- The encodings in this description are named to match the encodings of [AND, ANDS \(predicates\)](#).
- The description of [AND, ANDS \(predicates\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	1	0	0	Pm				0	1	Pg				0	Pn				0	Pd			
S																															

MOVS <Pd>.B, <Pg>/Z, <Pn>.B

is equivalent to

ANDS <Pd>.B, <Pg>/Z, <Pn>.B, <Pn>.B

and is the preferred disassembly when S == '1' && Pn == Pm.

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.

## Operation

The description of [AND, ANDS \(predicates\)](#) gives the operational pseudocode for this instruction.

# MOVS (unpredicated)

Move predicate (unpredicated), setting the condition flags

Read all elements from the source predicate and place in the destination predicate. This instruction is unpredicated. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

This is an alias of [ORR, ORRS \(predicates\)](#). This means:

- The encodings in this description are named to match the encodings of [ORR, ORRS \(predicates\)](#).
- The description of [ORR, ORRS \(predicates\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	1	1	0	0	Pm				0	1	Pg				0	Pn				0	Pd			
S																															

MOVS <Pd>.B, <Pn>.B

is equivalent to

ORRS <Pd>.B, <Pn>/Z, <Pn>.B, <Pn>.B

and is the preferred disassembly when S == '1' && Pn == Pm && Pm == Pg.

## Assembler Symbols

<Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.

<Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.

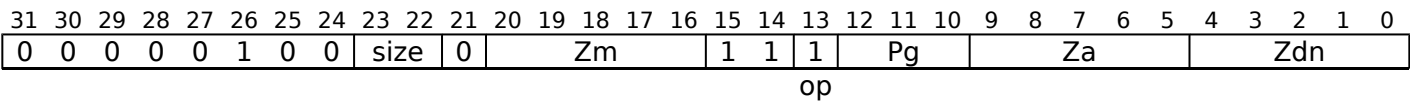
## Operation

The description of [ORR, ORRS \(predicates\)](#) gives the operational pseudocode for this instruction.

MSB

Multiply-subtract vectors (predicated), writing multiplicand [ $Zdn = Za - Zdn * Zm$ ]

Multiply the corresponding active elements of the first and second source vectors and subtract from elements of the third (addend) vector. Destructively place the results in the destination and first source (multiplicand) vector. Inactive elements in the destination vector register remain unmodified.



MSB <Zdn>.<T>, <Pg>/M, <Zm>.<T>, <Za>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
integer a = UInt(Za);
boolean sub_op = TRUE;
```

Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <Za> Is the name of the third source scalable vector register, encoded in the "Za" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) operand3 = if AnyActiveElement(mask, esize) then Z[a] else Zeros();
bits(VL) result;

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, e, esize]);
    integer product = element1 * element2;
    if sub_op then
      Elem[result, e, esize] = Elem[operand3, e, esize] - product;
    else
      Elem[result, e, esize] = Elem[operand3, e, esize] + product;
  else
    Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

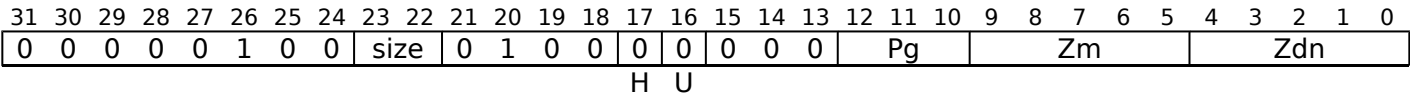
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# MUL (vectors)

Multiply vectors (predicated)

Multiply active elements of the first source vector by corresponding elements of the second source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



```
MUL <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, e, esize]);
    if ElemP[mask, e, esize] == '1' then
        integer product = element1 * element2;
        Elem[result, e, esize] = product<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.

- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# MUL (immediate)

Multiply by immediate (unpredicated)

Multiply by an immediate each element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate is a signed 8-bit value in the range -128 to +127, inclusive. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size		1	1	0	0	0	0	1	1	0	imm8								Zdn				

MUL <Zdn>.<T>, <Zdn>.<T>, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer dn = UInt(Zdn);
integer imm = SInt(imm8);
```

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<imm> Is the signed immediate operand, in the range -128 to 127, encoded in the "imm8" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, e, esize]);
    Elem[result, e, esize] = (element1 * imm)<esize-1:0>;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# NAND, NANDS

Bitwise NAND predicates

Bitwise NAND active elements of the second source predicate with corresponding elements of the first source predicate and place the results in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Optionally sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

It has encodings from 2 classes: [Not setting the condition flags](#) and [Setting the condition flags](#)

## Not setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	1	0	0	0	Pm			0	1	Pg			1	Pn			1	Pd						
S																															

NAND <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = FALSE;
```

## Setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	1	1	0	0	Pm			0	1	Pg			1	Pn			1	Pd						
S																															

NANDS <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = TRUE;
```

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.
- <Pm> Is the name of the second source scalable predicate register, encoded in the "Pm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(PL) operand1 = P[n];
bits(PL) operand2 = P[m];
bits(PL) result;

for e = 0 to elements-1
    bit element1 = ElemP[operand1, e, esize];
    bit element2 = ElemP[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        ElemP[result, e, esize] = NOT(element1 AND element2);
    else
        ElemP[result, e, esize] = '0';

if setflags then
    PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

NEG

Negate (predicated)

Negate the signed integer value in each active element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	0	1	1	1	1	0	1	Pg													

NEG <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) result = Z[d];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer element = SInt(Elem[operand, e, esize]);
        element = -element;
        Elem[result, e, esize] = element<esize-1:0>;

Z[d] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

# NOR, NORS

Bitwise NOR predicates

Bitwise NOR active elements of the second source predicate with corresponding elements of the first source predicate and place the results in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Optionally sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

It has encodings from 2 classes: [Not setting the condition flags](#) and [Setting the condition flags](#)

## Not setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	1	0	0	0	Pm			0	1	Pg			1	Pn			0	Pd						
S																															

NOR <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = FALSE;
```

## Setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	1	1	0	0	Pm			0	1	Pg			1	Pn			0	Pd						
S																															

NORS <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = TRUE;
```

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.
- <Pm> Is the name of the second source scalable predicate register, encoded in the "Pm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(PL) operand1 = P[n];
bits(PL) operand2 = P[m];
bits(PL) result;

for e = 0 to elements-1
    bit element1 = ElemP[operand1, e, esize];
    bit element2 = ElemP[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        ElemP[result, e, esize] = NOT(element1 OR element2);
    else
        ElemP[result, e, esize] = '0';

if setflags then
    PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# NOT (predicate)

Bitwise invert predicate

Bitwise invert each active element of the source predicate, and place the results in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Does not set the condition flags.

This is an alias of [EOR, EORS \(predicates\)](#). This means:

- The encodings in this description are named to match the encodings of [EOR, EORS \(predicates\)](#).
- The description of [EOR, EORS \(predicates\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	0	0	0	Pm				0	1	Pg				1	Pn				0	Pd			
S																															

NOT <Pd>.B, <Pg>/Z, <Pn>.B

is equivalent to

EOR <Pd>.B, <Pg>/Z, <Pn>.B, <Pg>.B

and is the preferred disassembly when Pm == Pg.

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.

## Operation

The description of [EOR, EORS \(predicates\)](#) gives the operational pseudocode for this instruction.

# NOT (vector)

Bitwise invert vector (predicated)

Bitwise invert each active element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	1	1	0	1	0	1	Pg													

NOT <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) result = Z[d];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element = Elem[operand, e, esize];
        Elem[result, e, esize] = NOT element;

Z[d] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

NOTS

Bitwise invert predicate, setting the condition flags

Bitwise invert each active element of the source predicate, and place the results in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

This is an alias of [EOR, EORS \(predicates\)](#). This means:

- The encodings in this description are named to match the encodings of [EOR, EORS \(predicates\)](#).
- The description of [EOR, EORS \(predicates\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	1	0	0	Pm				0	1	Pg			1	Pn			0	Pd					
S																															

NOTS <Pd>.B, <Pg>/Z, <Pn>.B

is equivalent to

EORS <Pd>.B, <Pg>/Z, <Pn>.B, <Pg>.B

and is the preferred disassembly when Pm == Pg.

Assembler Symbols

- <Pd>
- Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg>
- Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn>
- Is the name of the first source scalable predicate register, encoded in the "Pn" field.

Operation

The description of [EOR, EORS \(predicates\)](#) gives the operational pseudocode for this instruction.



# ORN (immediate)

Bitwise inclusive OR with inverted immediate (unpredicated)

Bitwise inclusive OR an inverted immediate with each 64-bit element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate is a 64-bit value consisting of a single run of ones or zeros repeating every 2, 4, 8, 16, 32 or 64 bits. This instruction is unpredicated.

This is a pseudo-instruction of [ORR \(immediate\)](#). This means:

- The encodings in this description are named to match the encodings of [ORR \(immediate\)](#).
- The assembler syntax is used only for assembly, and is not used on disassembly.
- The description of [ORR \(immediate\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	0	0	0	0	0	0	imm13												Zdn					

ORN <Zdn>.<T>, <Zdn>.<T>, #<const>

is equivalent to

ORR <Zdn>.<T>, <Zdn>.<T>, #(-<const> - 1)

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "imm13<12>:imm13<5:0>":

imm13<12>	imm13<5:0>	<T>
0	0xxxxx	S
0	10xxxx	H
0	110xxx	B
0	1110xx	B
0	11110x	B
0	111110	RESERVED
0	111111	RESERVED
1	xxxxxx	D

<const> Is a 64, 32, 16 or 8-bit bitmask consisting of replicated 2, 4, 8, 16, 32 or 64 bit fields, each field containing a rotated run of non-zero bits, encoded in the "imm13" field.

## Operation

The description of [ORR \(immediate\)](#) gives the operational pseudocode for this instruction.

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# ORN, ORNS (predicates)

Bitwise inclusive OR inverted predicate

Bitwise inclusive OR inverted active elements of the second source predicate with corresponding elements of the first source predicate and place the results in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Optionally sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

It has encodings from 2 classes: [Not setting the condition flags](#) and [Setting the condition flags](#)

## Not setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	1	0	0	0	Pm				0	1	Pg				0	Pn				1	Pd			
S																															

ORN <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = FALSE;
```

## Setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	1	1	0	0	Pm				0	1	Pg				0	Pn				1	Pd			
S																															

ORNS <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = TRUE;
```

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.
- <Pm> Is the name of the second source scalable predicate register, encoded in the "Pm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(PL) operand1 = P[n];
bits(PL) operand2 = P[m];
bits(PL) result;

for e = 0 to elements-1
    bit element1 = ElemP[operand1, e, esize];
    bit element2 = ElemP[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        ElemP[result, e, esize] = element1 OR (NOT element2);
    else
        ElemP[result, e, esize] = '0';

if setflags then
    PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# ORR, ORRS (predicates)

Bitwise inclusive OR predicate

Bitwise inclusive OR active elements of the second source predicate with corresponding elements of the first source predicate and place the results in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Optionally sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

This instruction is used by the aliases [MOVS \(unpredicated\)](#), and [MOV \(predicate, unpredicated\)](#).

It has encodings from 2 classes: [Not setting the condition flags](#) and [Setting the condition flags](#)

## Not setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	1	0	0	0	Pm			0	1	Pg			0	Pn			0	Pd						
S																															

ORR <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```

if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = FALSE;
```

## Setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	1	1	0	0	Pm			0	1	Pg			0	Pn			0	Pd						
S																															

ORRS <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```

if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = TRUE;
```

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.
- <Pm> Is the name of the second source scalable predicate register, encoded in the "Pm" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">MOVS (unpredicated)</a>	S == '1' && Pn == Pm && Pm == Pg
<a href="#">MOV (predicate, unpredicated)</a>	S == '0' && Pn == Pm && Pm == Pg

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(PL) operand1 = P[n];
bits(PL) operand2 = P[m];
bits(PL) result;

for e = 0 to elements-1
    bit element1 = ElemP[operand1, e, esize];
    bit element2 = ElemP[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        ElemP[result, e, esize] = element1 OR element2;
    else
        ElemP[result, e, esize] = '0';

if setflags then
    PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## ORR (vectors, predicated)

Bitwise inclusive OR vectors (predicated)

Bitwise inclusive OR active elements of the second source vector with corresponding elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	0	0	0	0	0	0	0	Pg	Zm				Zdn							

**ORR** <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

### Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = element1 OR element2;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];
Z[dn] = result;
```

### Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



# ORR (immediate)

Bitwise inclusive OR with immediate (unpredicated)

Bitwise inclusive OR an immediate with each 64-bit element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate is a 64-bit value consisting of a single run of ones or zeros repeating every 2, 4, 8, 16, 32 or 64 bits. This instruction is unpredicated.

This instruction is used by the pseudo-instruction [ORN \(immediate\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	0	0	0	0	0	0	imm13														Zdn			

ORR <Zdn>.<T>, <Zdn>.<T>, #<const>

```
if !HaveSVE() then UNDEFINED;
integer dn = UInt(Zdn);
bits(64) imm;
(imm, -) = DecodeBitMasks(imm13<12>, imm13<5:0>, imm13<11:6>, TRUE);
```

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "imm13<12>:imm13<5:0>":

imm13<12>	imm13<5:0>	<T>
0	0xxxxx	S
0	10xxxx	H
0	110xxx	B
0	1110xx	B
0	11110x	B
0	111110	RESERVED
0	111111	RESERVED
1	xxxxxx	D

<const> Is a 64, 32, 16 or 8-bit bitmask consisting of replicated 2, 4, 8, 16, 32 or 64 bit fields, each field containing a rotated run of non-zero bits, encoded in the "imm13" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV 64;
bits(VL) operand = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    bits(64) element1 = Elem[operand, e, 64];
    Elem[result, e, 64] = element1 OR imm;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.





# ORR (vectors, unpredicated)

Bitwise inclusive OR vectors (unpredicated)

Bitwise inclusive OR all elements of the second source vector with corresponding elements of the first source vector and place the first in the corresponding elements of the destination vector. This instruction is unpredicated.

This instruction is used by the alias [MOV \(vector, unpredicated\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1	Zm					0	0	1	1	0	0	Zn					Zd				

ORR <Zd>.D, <Zn>.D, <Zm>.D

```
if !HaveSVE() then UNDEFINED;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">MOV (vector, unpredicated)</a>	Zn == Zm

## Operation

```
CheckSVEEnabled();
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
Z[d] = operand1 OR operand2;
```

ORV

Bitwise inclusive OR reduction to scalar

Bitwise inclusive OR horizontally across all lanes of a vector, and place the result in the SIMD&FP scalar destination register. Inactive elements in the source vector are treated as zero.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	0	0	0	0	0	1	Pg													

ORV <V><d>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D

<d> Is the number [0-31] of the destination SIMD&FP register, encoded in the "Vd" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<T> Is the size specifier, encoded in “size”:

size	<T>
00	B
01	H
10	S
11	D

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(esize) result = Zeros(esize);

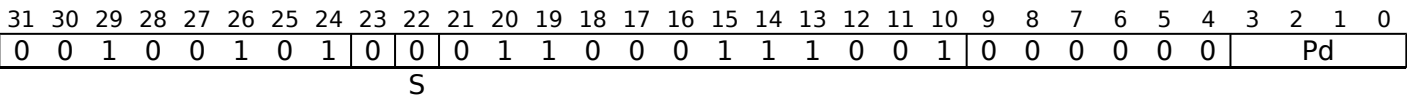
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        result = result OR Elem[operand, e, esize];

V[d] = result;
```

PFALSE

Set all predicate elements to false

Set all elements in the destination predicate to false.



PFALSE <Pd>.B

```
if !HaveSVE() then UNDEFINED;
integer d = UInt(Pd);
```

Assembler Symbols

<Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.

Operation

```
CheckSVEEnabled();
P[d] = Zeros(PL);
```

PFIRST

Set the first active predicate element to true

Sets the first active element in the destination predicate to true, otherwise elements from the source predicate are passed through unchanged. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	1	0	1	1	0	0	0	1	1	0	0	0	0	0	0	Pg			0	Pdn			
										S																					

PFIRST <Pdn>.B, <Pg>, <Pdn>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer dn = UInt(Pdn);
```

Assembler Symbols

- <Pdn> Is the name of the source and destination scalable predicate register, encoded in the "Pdn" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(PL) result = P[dn];
integer first = -1;

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' && first == -1 then
        first = e;

if first >= 0 then
    ElemP[result, first, esize] = '1';

PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[dn] = result;
```

PNEXT

Find next active predicate

An instruction used to construct a loop which iterates over all active elements in a predicate. If all source predicate elements are false it sets the first active predicate element in the destination predicate to true. Otherwise it determines the next active predicate element following the last true source predicate element, and if one is found sets the corresponding destination predicate element to true. All other destination predicate elements are set to false. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	0	1	1	0	0	1	1	1	0	0	0	1	0			Pg		0			Pdn		

PNEXT <Pdn>.<T>, <Pg>, <Pdn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Pdn);
```

Assembler Symbols

<Pdn> Is the name of the source and destination scalable predicate register, encoded in the "Pdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(PL) operand = P[dn];
bits(PL) result;

integer next = LastActiveElement(operand, esize) + 1;

while next < elements && (ElemP[mask, next, esize] == '0') do
    next = next + 1;

result = Zeros();
if next < elements then
    ElemP[result, next, esize] = '1';

PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[dn] = result;
```

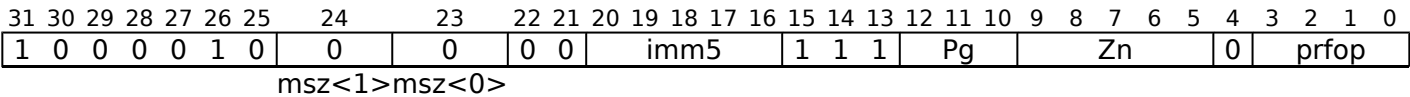
# PRFB (vector plus immediate)

Gather prefetch bytes (vector plus immediate)

Gather prefetch of bytes from the active memory addresses generated by a vector base plus immediate index. The index is in the range 0 to 31. Inactive addresses are not prefetched from memory.  
The <prfop> symbol specifies the prefetch hint as a combination of three options: access type PLD for load or PST for store; target cache level L1, L2 or L3; temporality (KEEP for temporal or STRM for non-temporal).

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

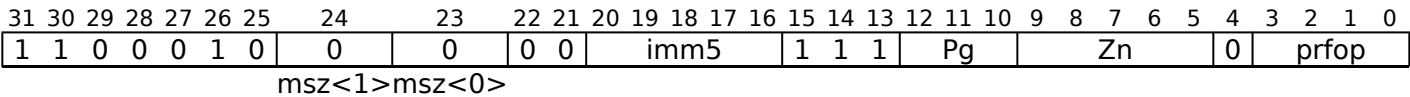
## 32-bit element



PRFB <prfop>, <Pg>, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 0;
integer offset = UInt(imm5);
```

## 64-bit element



PRFB <prfop>, <Pg>, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 0;
integer offset = UInt(imm5);
```

## Assembler Symbols

<prfop> Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, in the range 0 to 31, defaulting to 0, encoded in the "imm5" field.

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) base;

if AnyActiveElement(mask, esize) then
    base = Z[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = ZeroExtend(Elem[base, e, esize], 64) + (offset << scale);
        Hint_Prefetch(addr, pref_hint, level, stream);

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

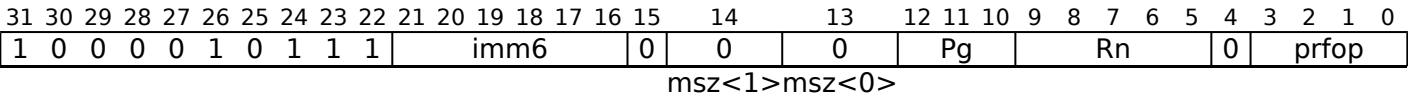


PRFB (scalar plus immediate)

Contiguous prefetch bytes (immediate index)

Contiguous prefetch of byte elements from the memory address generated by a 64-bit scalar base and immediate index in the range -32 to 31 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address.

The predicate may be used to suppress prefetches from unwanted addresses.



PRFB <prfop>, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 0;
integer offset = SInt(imm6);
```

Assembler Symbols

<prfop> Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -32 to 31, defaulting to 0, encoded in the "imm6" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;

if AnyActiveElement(mask, esize) then
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + (eoff << scale);
        Hint_Prefetch(addr, pref_hint, level, stream);
```

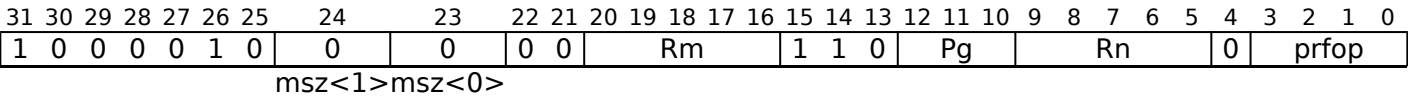
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

PRFB (scalar plus scalar)

Contiguous prefetch bytes (scalar index)

Contiguous prefetch of byte elements from the memory address generated by a 64-bit scalar base and scalar index which is added to the base address. After each element prefetch the index value is incremented, but the index register is not updated.  
The predicate may be used to suppress prefetches from unwanted addresses.



PRFB <prfop>, <Pg>, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 0;
```

Assembler Symbols

<prfop> Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;
bits(64) offset;

if AnyActiveElement(mask, esize) then
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = UInt(offset) + e;
        bits(64) addr = base + (eoff << scale);
        Hint_Prefetch(addr, pref_hint, level, stream);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## PRFB (scalar plus vector)

Gather prefetch bytes (scalar plus vector)

Gather prefetch of bytes from the active memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally sign or zero-extended from 32 to 64 bits. Inactive addresses are not prefetched from memory.

The <prfop> symbol specifies the prefetch hint as a combination of three options: access type PLD for load or PST for store; target cache level L1, L2 or L3; temporality (KEEP for temporal or STRM for non-temporal).

It has encodings from 3 classes: [32-bit scaled offset](#) , [32-bit unpacked scaled offset](#) and [64-bit scaled offset](#)

### 32-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	0	xs	1	Zm			0	0	0	Pg	Rn			0	prfop									
msz<1>msz<0>																															

PRFB <prfop>, <Pg>, [<Xn|SP>, <Zm>.S, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer offs_size = 32;
boolean offs_unsigned = (xs == '0');
integer scale = 0;
```

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	xs	1	Zm			0	0	0	Pg	Rn			0	prfop									
msz<1>msz<0>																															

PRFB <prfop>, <Pg>, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer offs_size = 32;
boolean offs_unsigned = (xs == '0');
integer scale = 0;
```

### 64-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	1	1	Zm			1	0	0	Pg	Rn			0	prfop									
																msz<1>msz<0>															

PRFB <prfop>, <Pg>, [<Xn|SP>, <Zm>.D]

```

if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer offs_size = 64;
boolean offs_unsigned = TRUE;
integer scale = 0;

```

## Assembler Symbols

<prfop> Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

<Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.

<mod> Is the index extend and shift specifier, encoded in “xs”:

xs	<mod>
0	UXTW
1	SXTW

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;
bits(VL) offset;

if AnyActiveElement(mask, esize) then
    base = if n == 31 then SP[] else X[n];
    offset = Z[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        bits(64) addr = base + (off << scale);
        Hint_Prefetch(addr, pref_hint, level, stream);

```

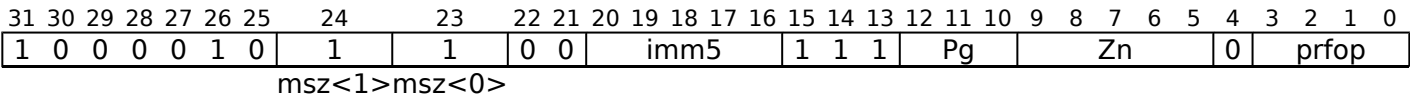
# PRFD (vector plus immediate)

Gather prefetch doublewords (vector plus immediate)

Gather prefetch of doublewords from the active memory addresses generated by a vector base plus immediate index. The index is a multiple of 8 in the range 0 to 248. Inactive addresses are not prefetched from memory. The <prfop> symbol specifies the prefetch hint as a combination of three options: access type PLD for load or PST for store; target cache level L1, L2 or L3; temporality (KEEP for temporal or STRM for non-temporal).

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

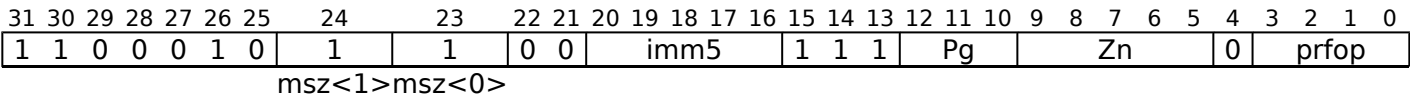
## 32-bit element



PRFD <prfop>, <Pg>, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 3;
integer offset = UInt(imm5);
```

## 64-bit element



PRFD <prfop>, <Pg>, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 3;
integer offset = UInt(imm5);
```

## Assembler Symbols

<prfop> Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 8 in the range 0 to 248, defaulting to 0, encoded in the "imm5" field.

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) base;

if AnyActiveElement(mask, esize) then
    base = Z[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = ZeroExtend(Elem[base, e, esize], 64) + (offset << scale);
        Hint_Prefetch(addr, pref_hint, level, stream);

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

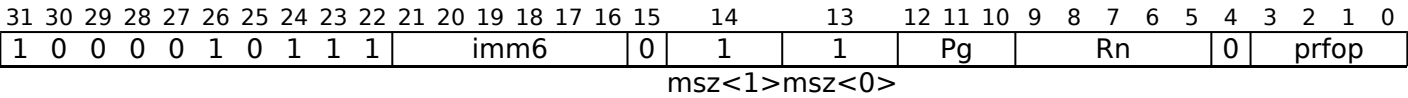


PRFD (scalar plus immediate)

Contiguous prefetch doublewords (immediate index)

Contiguous prefetch of doubleword elements from the memory address generated by a 64-bit scalar base and immediate index in the range -32 to 31 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address.

The predicate may be used to suppress prefetches from unwanted addresses.



PRFD <prfop>, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 3;
integer offset = SInt(imm6);
```

Assembler Symbols

<prfop> Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -32 to 31, defaulting to 0, encoded in the "imm6" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;

if AnyActiveElement(mask, esize) then
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + (eoff << scale);
        Hint_Prefetch(addr, pref_hint, level, stream);
```

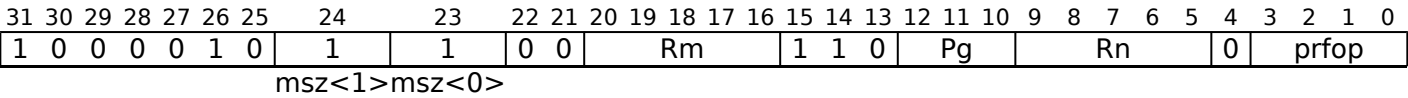
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

PRFD (scalar plus scalar)

Contiguous prefetch doublewords (scalar index)

Contiguous prefetch of doubleword elements from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 8 and added to the base address. After each element prefetch the index value is incremented, but the index register is not updated.  
The predicate may be used to suppress prefetches from unwanted addresses.



PRFD <prfop>, <Pg>, [<Xn|SP>, <Xm>, LSL #3]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 3;
```

Assembler Symbols

<prfop> Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;
bits(64) offset;

if AnyActiveElement(mask, esize) then
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = UInt(offset) + e;
        bits(64) addr = base + (eoff << scale);
        Hint_Prefetch(addr, pref_hint, level, stream);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# PRFD (scalar plus vector)

Gather prefetch doublewords (scalar plus vector)

Gather prefetch of doublewords from the active memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then multiplied by 8. Inactive addresses are not prefetched from memory.  
The <prfop> symbol specifies the prefetch hint as a combination of three options: access type PLD for load or PST for store; target cache level L1, L2 or L3; temporality (KEEP for temporal or STRM for non-temporal).

It has encodings from 3 classes: [32-bit scaled offset](#) , [32-bit unpacked scaled offset](#) and [64-bit scaled offset](#)

## 32-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	0	xs	1	Zm			0	1	1	Pg	Rn			0	prfop									
																msz<1>msz<0>															

PRFD <prfop>, <Pg>, [<Xn|SP>, <Zm>.S, <mod> #3]

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer offs_size = 32;
boolean offs_unsigned = (xs == '0');
integer scale = 3;
```

## 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	xs	1	Zm			0	1	1	Pg	Rn			0	prfop									
																msz<1>msz<0>															

PRFD <prfop>, <Pg>, [<Xn|SP>, <Zm>.D, <mod> #3]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer offs_size = 32;
boolean offs_unsigned = (xs == '0');
integer scale = 3;
```

## 64-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	1	1	Zm			1	1	1	Pg	Rn			0	prfop									
																msz<1>msz<0>															

PRFD <prfop>, <Pg>, [<Xn|SP>, <Zm>.D, LSL #3]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer offs_size = 64;
boolean offs_unsigned = TRUE;
integer scale = 3;
```

Assembler Symbols

<prfop> Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

<Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.

<mod> Is the index extend and shift specifier, encoded in “xs”:

xs	<mod>
0	UXTW
1	SXTW

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;
bits(VL) offset;

if AnyActiveElement(mask, esize) then
    base = if n == 31 then SP[] else X[n];
    offset = Z[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        bits(64) addr = base + (off << scale);
        Hint_Prefetch(addr, pref_hint, level, stream);
```

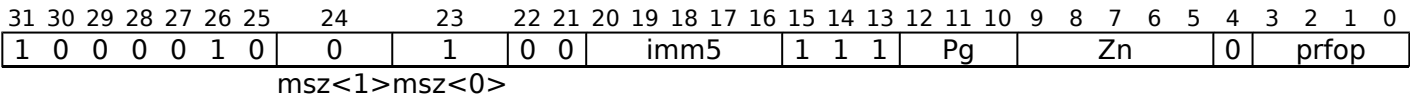
# PRFH (vector plus immediate)

Gather prefetch halfwords (vector plus immediate)

Gather prefetch of halfwords from the active memory addresses generated by a vector base plus immediate index. The index is a multiple of 2 in the range 0 to 62. Inactive addresses are not prefetched from memory. The <prfop> symbol specifies the prefetch hint as a combination of three options: access type PLD for load or PST for store; target cache level L1, L2 or L3; temporality (KEEP for temporal or STRM for non-temporal).

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

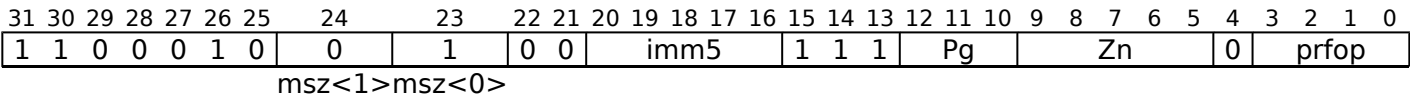
## 32-bit element



PRFH <prfop>, <Pg>, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 1;
integer offset = UInt(imm5);
```

## 64-bit element



PRFH <prfop>, <Pg>, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 1;
integer offset = UInt(imm5);
```

## Assembler Symbols

<prfop> Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 2 in the range 0 to 62, defaulting to 0, encoded in the "imm5" field.

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) base;

if AnyActiveElement(mask, esize) then
    base = Z[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = ZeroExtend(Elem[base, e, esize], 64) + (offset << scale);
        Hint_Prefetch(addr, pref_hint, level, stream);

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

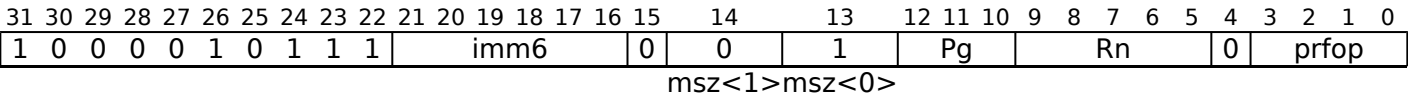
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



PRFH (scalar plus immediate)

Contiguous prefetch halfwords (immediate index)

Contiguous prefetch of halfword elements from the memory address generated by a 64-bit scalar base and immediate index in the range -32 to 31 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address.  
The predicate may be used to suppress prefetches from unwanted addresses.



PRFH <prfop>, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 1;
integer offset = SInt(imm6);
```

Assembler Symbols

<prfop> Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -32 to 31, defaulting to 0, encoded in the "imm6" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;

if AnyActiveElement(mask, esize) then
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + (eoff << scale);
        Hint_Prefetch(addr, pref_hint, level, stream);
```

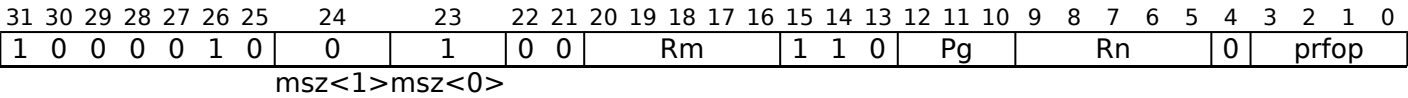
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

PRFH (scalar plus scalar)

Contiguous prefetch halfwords (scalar index)

Contiguous prefetch of halfword elements from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 2 and added to the base address. After each element prefetch the index value is incremented, but the index register is not updated.  
The predicate may be used to suppress prefetches from unwanted addresses.



PRFH <prfop>, <Pg>, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer esize = 16;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 1;
```

Assembler Symbols

<prfop> Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;
bits(64) offset;

if AnyActiveElement(mask, esize) then
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = UInt(offset) + e;
        bits(64) addr = base + (eoff << scale);
        Hint_Prefetch(addr, pref_hint, level, stream);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## PRFH (scalar plus vector)

Gather prefetch halfwords (scalar plus vector)

Gather prefetch of halfwords from the active memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then multiplied by 2. Inactive addresses are not prefetched from memory.

The <prfop> symbol specifies the prefetch hint as a combination of three options: access type PLD for load or PST for store; target cache level L1, L2 or L3; temporality (KEEP for temporal or STRM for non-temporal).

It has encodings from 3 classes: [32-bit scaled offset](#) , [32-bit unpacked scaled offset](#) and [64-bit scaled offset](#)

### 32-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	0	xs	1	Zm			0	0	1	Pg			Rn			0	prfop							
msz<1>msz<0>																															

PRFH <prfop>, <Pg>, [<Xn|SP>, <Zm>.S, <mod> #1]

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer offs_size = 32;
boolean offs_unsigned = (xs == '0');
integer scale = 1;
```

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	xs	1	Zm			0	0	1	Pg			Rn			0	prfop							
msz<1>msz<0>																															

PRFH <prfop>, <Pg>, [<Xn|SP>, <Zm>.D, <mod> #1]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer offs_size = 32;
boolean offs_unsigned = (xs == '0');
integer scale = 1;
```

### 64-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	1	1	Zm			1	0	1	Pg			Rn			0	prfop							
																msz<1>msz<0>															

PRFH <prfop>, <Pg>, [<Xn|SP>, <Zm>.D, LSL #1]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer offs_size = 64;
boolean offs_unsigned = TRUE;
integer scale = 1;
```

Assembler Symbols

<prfop> Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

<Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.

<mod> Is the index extend and shift specifier, encoded in “xs”:

xs	<mod>
0	UXTW
1	SXTW

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;
bits(VL) offset;

if AnyActiveElement(mask, esize) then
    base = if n == 31 then SP[] else X[n];
    offset = Z[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        bits(64) addr = base + (off << scale);
        Hint_Prefetch(addr, pref_hint, level, stream);
```

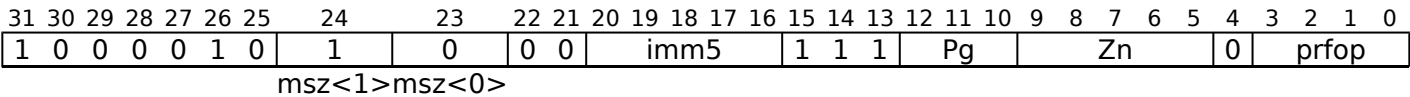
# PRFW (vector plus immediate)

Gather prefetch words (vector plus immediate)

Gather prefetch of words from the active memory addresses generated by a vector base plus immediate index. The index is a multiple of 4 in the range 0 to 124. Inactive addresses are not prefetched from memory. The <prfop> symbol specifies the prefetch hint as a combination of three options: access type PLD for load or PST for store; target cache level L1, L2 or L3; temporality (KEEP for temporal or STRM for non-temporal).

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

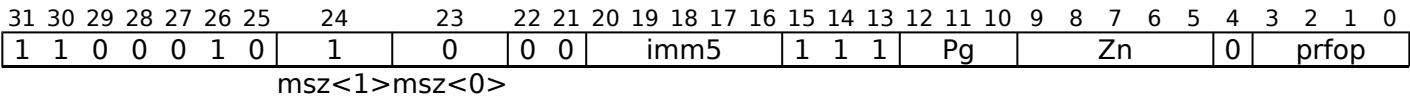
## 32-bit element



PRFW <prfop>, <Pg>, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 2;
integer offset = UInt(imm5);
```

## 64-bit element



PRFW <prfop>, <Pg>, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 2;
integer offset = UInt(imm5);
```

## Assembler Symbols

<prfop> Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 4 in the range 0 to 124, defaulting to 0, encoded in the "imm5" field.

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) base;

if AnyActiveElement(mask, esize) then
    base = Z[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = ZeroExtend(Elem[base, e, esize], 64) + (offset << scale);
        Hint_Prefetch(addr, pref_hint, level, stream);

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

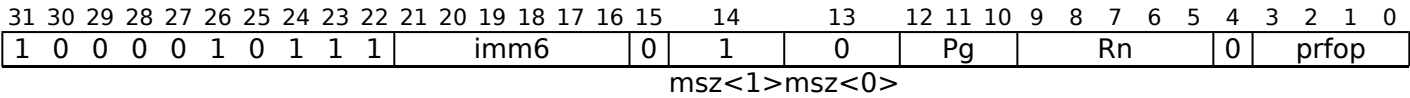


PRFW (scalar plus immediate)

Contiguous prefetch words (immediate index)

Contiguous prefetch of word elements from the memory address generated by a 64-bit scalar base and immediate index in the range -32 to 31 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address.

The predicate may be used to suppress prefetches from unwanted addresses.



PRFW <prfop>, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 2;
integer offset = SInt(imm6);
```

Assembler Symbols

<prfop> Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -32 to 31, defaulting to 0, encoded in the "imm6" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;

if AnyActiveElement(mask, esize) then
    base = if n == 31 then SP[] else X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + (eoff << scale);
        Hint_Prefetch(addr, pref_hint, level, stream);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

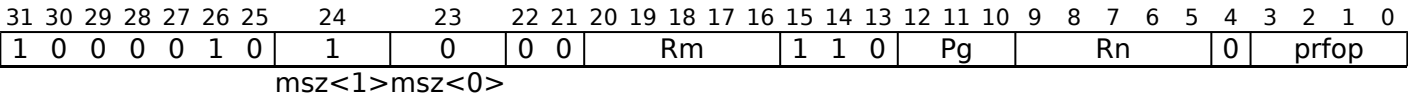
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

PRFW (scalar plus scalar)

Contiguous prefetch words (scalar index)

Contiguous prefetch of word elements from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 4 and added to the base address. After each element prefetch the index value is incremented, but the index register is not updated.

The predicate may be used to suppress prefetches from unwanted addresses.



PRFW <prfop>, <Pg>, [<Xn|SP>, <Xm>, LSL #2]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 2;
```

Assembler Symbols

<prfop> Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;
bits(64) offset;

if AnyActiveElement(mask, esize) then
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = UInt(offset) + e;
        bits(64) addr = base + (eoff << scale);
        Hint_Prefetch(addr, pref_hint, level, stream);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## PRFW (scalar plus vector)

Gather prefetch words (scalar plus vector)

Gather prefetch of words from the active memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then multiplied by 4. Inactive addresses are not prefetched from memory.

The <prfop> symbol specifies the prefetch hint as a combination of three options: access type PLD for load or PST for store; target cache level L1, L2 or L3; temporality (KEEP for temporal or STRM for non-temporal).

It has encodings from 3 classes: [32-bit scaled offset](#) , [32-bit unpacked scaled offset](#) and [64-bit scaled offset](#)

### 32-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	0	xs	1	Zm			0	1	0	Pg			Rn			0	prfop							
msz<1>msz<0>																															

PRFW <prfop>, <Pg>, [<Xn|SP>, <Zm>.S, <mod> #2]

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer offs_size = 32;
boolean offs_unsigned = (xs == '0');
integer scale = 2;
```

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	xs	1	Zm			0	1	0	Pg			Rn			0	prfop							
msz<1>msz<0>																															

PRFW <prfop>, <Pg>, [<Xn|SP>, <Zm>.D, <mod> #2]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer offs_size = 32;
boolean offs_unsigned = (xs == '0');
integer scale = 2;
```

### 64-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	1	1	Zm			1	1	0	Pg			Rn			0	prfop							
																msz<1>msz<0>															

PRFW <prfop>, <Pg>, [<Xn|SP>, <Zm>.D, LSL #2]

```

if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer offs_size = 64;
boolean offs_unsigned = TRUE;
integer scale = 2;

```

### Assembler Symbols

<prfop> Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

<Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.

<mod> Is the index extend and shift specifier, encoded in “xs”:

xs	<mod>
0	UXTW
1	SXTW

### Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;
bits(VL) offset;

if AnyActiveElement(mask, esize) then
    base = if n == 31 then SP[] else X[n];
    offset = Z[m];

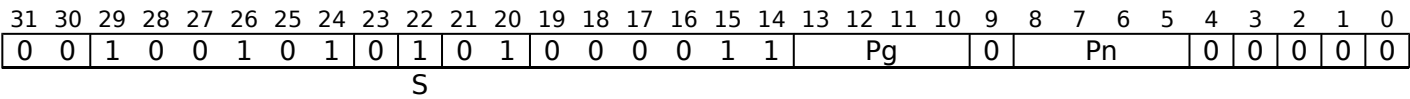
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        bits(64) addr = base + (off << scale);
        Hint_Prefetch(addr, pref_hint, level, stream);

```

PTEST

Set condition flags for predicate

Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate source register, and the V flag to zero.



PTEST <Pg>, <Pn>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
```

Assembler Symbols

- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the source scalable predicate register, encoded in the "Pn" field.

Operation

```
CheckSVEEnabled();
bits(PL) mask = P[g];
bits(PL) result = P[n];
PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
```

PTRUE, PTRUES

Initialise predicate from named constraint

Set elements of the destination predicate to true if the element number satisfies the named predicate constraint, or to false otherwise. If the constraint specifies more elements than are available at the current vector length then all elements of the destination predicate are set to false.  
The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception. Optionally sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

It has encodings from 2 classes: [Not setting the condition flags](#) and [Setting the condition flags](#)

Not setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	0	1	1	0	0	0	0	1	1	1	0	0	0	pattern	0								Pd
S																															

PTRUE <Pd>.<T>{, <pattern>}

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer d = UInt(Pd);
boolean setflags = FALSE;
bits(5) pat = pattern;
```

Setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	0	1	1	0	0	1	1	1	1	0	0	0	pattern			0	Pd						
S																															

PTRUES <Pd>.<T>{, <pattern>}

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer d = UInt(Pd);
boolean setflags = TRUE;
bits(5) pat = pattern;
```

Assembler Symbols

<Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":



pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
integer count = DecodePredCount(pat, esize);
bits(PL) result;

for e = 0 to elements-1
    ElemP[result, e, esize] = if e < count then '1' else '0';

if setflags then
    PSTATE.<N,Z,C,V> = PredTest(result, result, esize);
P[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# PUNPKHI, PUNPKLO

Unpack and widen half of predicate

Unpack elements from the lowest or highest half of the source predicate and place in elements of twice their size within the destination predicate. This instruction is unpredicated.

It has encodings from 2 classes: [High half](#) and [Low half](#)

## High half

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	0	0	1	1	0	0	0	1	0	1	0	0	0	0	0	0	Pn			0	Pd			
H																															

PUNPKHI [<Pd>](#).H, [<Pn>](#).B

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer n = UInt(Pn);
integer d = UInt(Pd);
boolean hi = TRUE;
```

## Low half

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	Pn			0	Pd			
H																															

PUNPKLO [<Pd>](#).H, [<Pn>](#).B

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer n = UInt(Pn);
integer d = UInt(Pd);
boolean hi = FALSE;
```

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pn> Is the name of the source scalable predicate register, encoded in the "Pn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) operand = P[n];
bits(PL) result;

for e = 0 to elements-1
    ElemP[result, e, esize] = ElemP[operand, if hi then e + elements else e, esize DIV 2];
P[d] = result;
```

RBIT

Reverse bits (predicated)

Reverse bits in each active element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	0	1	1	1	1	0	0	Pg													

RBIT <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) result = Z[d];

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    bits(esize) element = Elem[operand, e, esize];
    Elem[result, e, esize] = BitReverse(element);

Z[d] = result;
```

Operational information

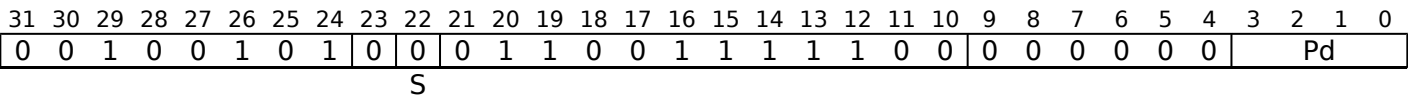
This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

# RDFFR (unpredicated)

Read the first-fault register

Read the first-fault register (FFR) and place in the destination predicate without predication.



**RDFFR** <Pd>.B

```
if !HaveSVE() then UNDEFINED;
integer d = UInt(Pd);
```

## Assembler Symbols

<Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.

## Operation

```
CheckSVEEnabled();
bits(PL) ffr = FFR[];
P[d] = ffr;
```

# RDFFR, RDFFRS (predicated)

Return predicate of succesfully loaded elements

Read the first-fault register (FFR) and place active elements in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Optionally sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

It has encodings from 2 classes: [Not setting the condition flags](#) and [Setting the condition flags](#)

## Not setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	0	0	1	1	0	0	0	1	1	1	1	0	0	0	Pg			0	Pd				
S																															

RDFFR <Pd>.B, <Pg>/Z

```
if !HaveSVE() then UNDEFINED;
integer g = UInt(Pg);
integer d = UInt(Pd);
boolean setflags = FALSE;
```

## Setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	1	0	1	1	0	0	0	1	1	1	1	0	0	0	Pg			0	Pd				
S																															

RDFFRS <Pd>.B, <Pg>/Z

```
if !HaveSVE() then UNDEFINED;
integer g = UInt(Pg);
integer d = UInt(Pd);
boolean setflags = TRUE;
```

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.

## Operation

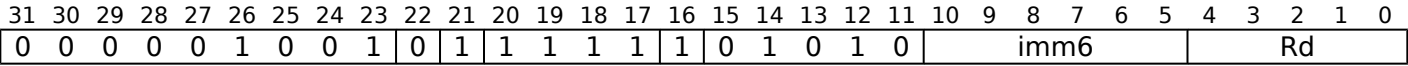
```
CheckSVEEnabled();
bits(PL) mask = P[g];
bits(PL) ffr = FFR[];
bits(PL) result = ffr AND mask;

if setflags then
    PSTATE.<N,Z,C,V> = PredTest(mask, result, 8);
P[d] = result;
```

# RDVL

Read multiple of vector register size to scalar register

Multiply the current vector register size in bytes by an immediate in the range -32 to 31 and place the result in the 64-bit destination general-purpose register.



RDVL <Xd>, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer d = UInt(Rd);
integer imm = SInt(imm6);
```

## Assembler Symbols

- <Xd> Is the 64-bit name of the destination general-purpose register, encoded in the "Rd" field.
- <imm> Is the signed immediate operand, in the range -32 to 31, encoded in the "imm6" field.

## Operation

```
CheckSVEEnabled();
integer len = imm * (VL DIV 8);
X[d] = len<63:0>;
```

# REV (predicate)

Reverse all elements in a predicate

Reverse the order of all elements in the source predicate and place in the destination predicate. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	1	0	1	0	0	0	1	0	0	0	0	0	0	0	Pn			0	Pd			

REV <Pd>.<T>, <Pn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Pn);
integer d = UInt(Pd);
```

## Assembler Symbols

<Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pn> Is the name of the source scalable predicate register, encoded in the "Pn" field.

## Operation

```
CheckSVEEnabled();
bits(PL) operand = P[n];
bits(PL) result = Reverse(operand, esize DIV 8);
P[d] = result;
```

# REV (vector)

Reverse all elements in a vector (unpredicated)

Reverse the order of all elements in the source vector and place in the destination vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	1	1	0	0	0	0	0	1	1	1	0	Zn				Zd						

REV <Zd>.<T>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
bits(VL) operand = Z[n];
bits(VL) result = Reverse(operand, esize);
Z[d] = result;
```



# REVB, REVH, REVW

Reverse bytes / halfwords / words within elements (predicated)

Reverse the order of 8-bit bytes, 16-bit halfwords or 32-bit words within each active element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

It has encodings from 3 classes: [Byte](#) , [Halfword](#) and [Word](#)

## Byte

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	0	1	0	0	1	0	0	Pg													

REVB <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer ssize = 8;
```

## Halfword

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	0	1	0	1	1	0	0	Pg													

REVH <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size != '1x' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer ssize = 16;
```

## Word

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	0	1	1	0	1	0	0	Pg													

REWV <Zd>.D, <Pg>/M, <Zn>.D

```
if !HaveSVE() then UNDEFINED;
if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer ssize = 32;
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> For the byte variant: is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

For the halfword variant: is the size specifier, encoded in "size<0>":

size<0>	<T>
0	S
1	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) result = Z[d];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element = Elem[operand, e, esize];
        Elem[result, e, esize] = Reverse(element, swsize);

Z[d] = result;

```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

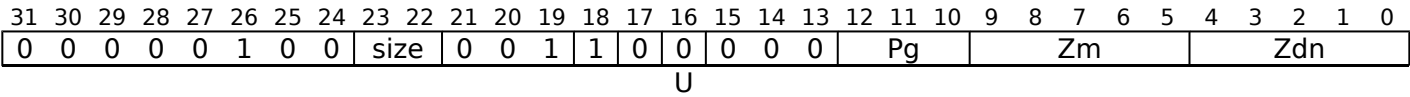
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SABD

Signed absolute difference (predicated)

Compute the absolute difference between signed integer values in active elements of the second source vector and corresponding elements of the first source vector and destructively place the difference in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



SABD <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean unsigned = FALSE;
```

Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    if ElemP[mask, e, esize] == '1' then
        integer absdiff = Abs(element1 - element2);
        Elem[result, e, esize] = absdiff<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

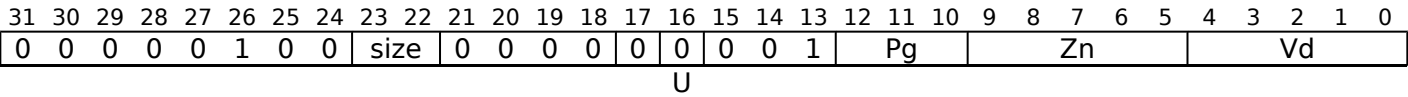
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SADDV

Signed add reduction to scalar

Signed add horizontally across all lanes of a vector, and place the result in the SIMD&FP scalar destination register. Narrow elements are first sign-extended to 64 bits. Inactive elements in the source vector are treated as zero.



SADDV <Dd>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
```

Assembler Symbols

- <Dd> Is the 64-bit name of the destination SIMD&FP register, encoded in the "Vd" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	RESERVED

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
integer sum = 0;

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer element = SInt(Elem[operand, e, esize]);
        sum = sum + element;

V[d] = sum<63:0>;
```

# SCVTF

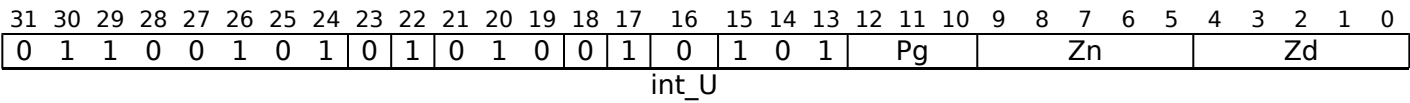
Signed integer convert to floating-point (predicated)

Convert to floating-point from the signed integer in each active element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

If the input and result types have a different size the smaller type is held unpacked in the least significant bits of elements of the larger size. When the input is the smaller type the upper bits of each source element are ignored. When the result is the smaller type the results are zero-extended to fill each destination element.

It has encodings from 7 classes: [16-bit to half-precision](#) , [32-bit to half-precision](#) , [32-bit to single-precision](#) , [32-bit to double-precision](#) , [64-bit to half-precision](#) , [64-bit to single-precision](#) and [64-bit to double-precision](#)

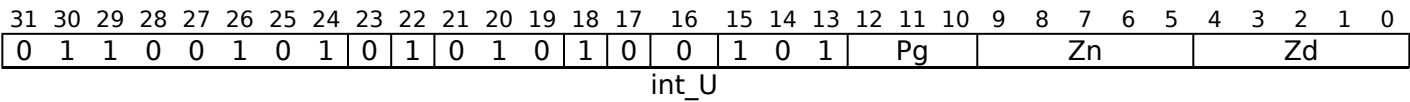
## 16-bit to half-precision



SCVTF <Zd>.H, <Pg>/M, <Zn>.H

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 16;
integer d_esize = 16;
boolean unsigned = FALSE;
FPRounding rounding = FPRoundingMode(FPCR[]);
```

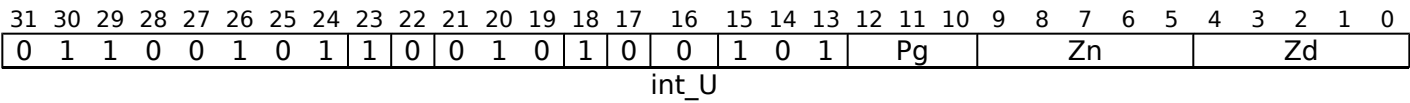
## 32-bit to half-precision



SCVTF <Zd>.H, <Pg>/M, <Zn>.S

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 32;
integer d_esize = 16;
boolean unsigned = FALSE;
FPRounding rounding = FPRoundingMode(FPCR[]);
```

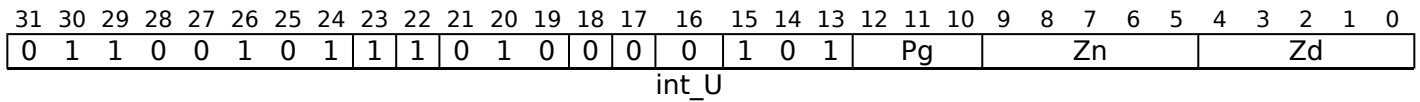
## 32-bit to single-precision



SCVTF <Zd>.S, <Pg>/M, <Zn>.S

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 32;
integer d_esize = 32;
boolean unsigned = FALSE;
FPRounding rounding = FPRoundingMode(FPCR[]);
```

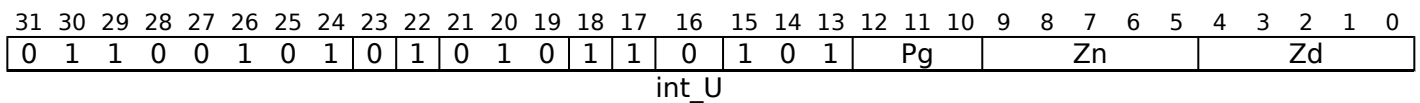
### 32-bit to double-precision



SCVTF <Zd>.D, <Pg>/M, <Zn>.S

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 32;
integer d_esize = 64;
boolean unsigned = FALSE;
FPRounding rounding = FPRoundingMode(FPCR[]);
```

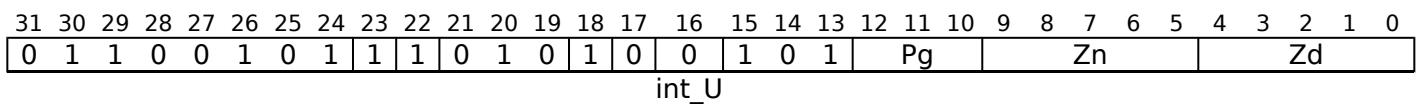
### 64-bit to half-precision



SCVTF <Zd>.H, <Pg>/M, <Zn>.D

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 64;
integer d_esize = 16;
boolean unsigned = FALSE;
FPRounding rounding = FPRoundingMode(FPCR[]);
```

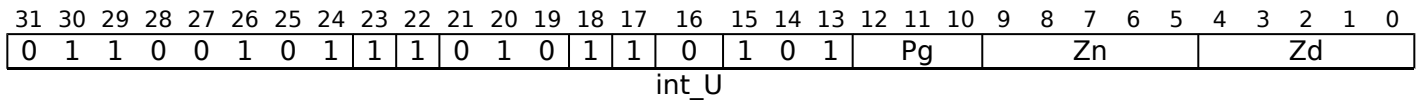
### 64-bit to single-precision



SCVTF <Zd>.S, <Pg>/M, <Zn>.D

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 64;
integer d_esize = 32;
boolean unsigned = FALSE;
FPRounding rounding = FPRoundingMode(FPCR[]);
```

## 64-bit to double-precision



SCVTF <Zd>.D, <Pg>/M, <Zn>.D

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 64;
integer d_esize = 64;
boolean unsigned = FALSE;
FPRounding rounding = FPRoundingMode(FPCR[]);
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) result = Z[d];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element = Elem[operand, e, esize];
        bits(d_esize) fpval = FixedToFP(element<s_esize-1:0>, 0, unsigned, FPCR[], rounding);
        Elem[result, e, esize] = ZeroExtend(fpval);

Z[d] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

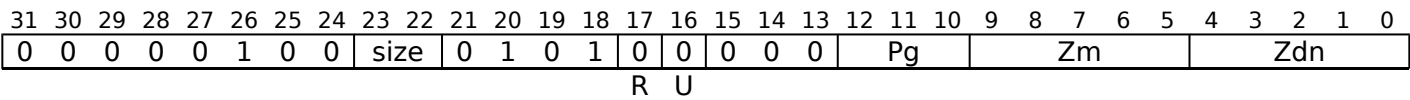




# SDIV

Signed divide (predicated)

Signed divide active elements of the first source vector by corresponding elements of the second source vector and destructively place the quotient in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



SDIV <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '0x' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean unsigned = FALSE;
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size<0>":

size<0>	<T>
0	S
1	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    if ElemP[mask, e, esize] == '1' then
        integer element2 = Int(Elem[operand2, e, esize], unsigned);
        integer quotient;
        if element2 == 0 then
            quotient = 0;
        else
            quotient = RoundTowardsZero(Real(element1) / Real(element2));
        Elem[result, e, esize] = quotient<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

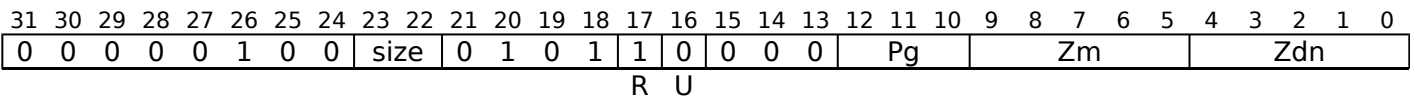
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SDIVR

Signed reversed divide (predicated)

Signed reversed divide active elements of the second source vector by corresponding elements of the first source vector and destructively place the quotient in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



```
SDIVR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>
```

```
if !HaveSVE() then UNDEFINED;
if size == '0x' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean unsigned = FALSE;
```

Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size<0>":

size<0>	<T>
0	S
1	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    if ElemP[mask, e, esize] == '1' then
        integer element2 = Int(Elem[operand2, e, esize], unsigned);
        integer quotient;
        if element1 == 0 then
            quotient = 0;
        else
            quotient = RoundTowardsZero(Real(element2) / Real(element1));
        Elem[result, e, esize] = quotient<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

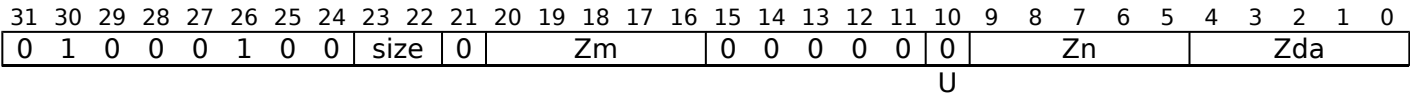
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SDOT (vectors)

Signed integer dot product

The signed integer dot product instruction computes the dot product of a group of four signed 8-bit or 16-bit integer values held in each 32-bit or 64-bit element of the first source vector multiplied by a group of four signed 8-bit or 16-bit integer values in the corresponding 32-bit or 64-bit element of the second source vector, and then destructively adds the widened dot product to the corresponding 32-bit or 64-bit element of the destination vector.

This instruction is unpredicated.



SDOT <Zda>.<T>, <Zn>.<Tb>, <Zm>.<Tb>

```
if !HaveSVE() then UNDEFINED;
if size == '0x' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

<Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.

<T> Is the size specifier, encoded in "size<0>":

size<0>	<T>
0	S
1	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size<0>":

size<0>	<Tb>
0	B
1	H

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) res = Elem[operand3, e, esize];
    for i = 0 to 3
        integer element1 = SInt(Elem[operand1, 4 * e + i, esize DIV 4]);
        integer element2 = SInt(Elem[operand2, 4 * e + i, esize DIV 4]);
        res = res + element1 * element2;
    Elem[result, e, esize] = res;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SDOT (indexed)

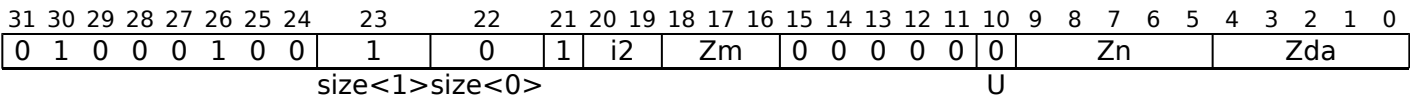
Signed integer indexed dot product

The signed integer indexed dot product instruction computes the dot product of a group of four signed 8-bit or 16-bit integer values held in each 32-bit or 64-bit element of the first source vector multiplied by a group of four signed 8-bit or 16-bit integer values in an indexed 32-bit or 64-bit element of the second source vector, and then destructively adds the widened dot product to the corresponding 32-bit or 64-bit element of the destination vector.

The groups within the second source vector are specified using an immediate index which selects the same group position within each 128-bit vector segment. The index range is from 0 to one less than the number of groups per 128-bit segment, encoded in 1 to 2 bits depending on the size of the group. This instruction is unpredicated.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

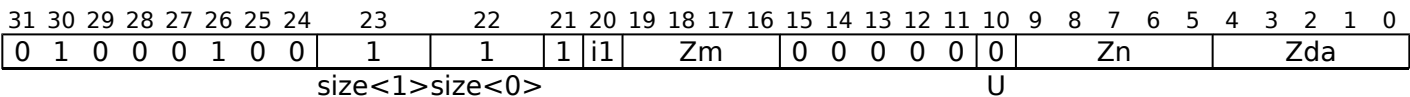
## 32-bit



SDOT <Zda>.S, <Zn>.B, <Zm>.B[<imm>]

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## 64-bit



SDOT <Zda>.D, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer index = UInt(i1);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> For the 32-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  
For the 64-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
- <imm> For the 32-bit variant: is the immediate index of a quadruplet of four 8-bit elements within each 128-bit vector segment, in the range 0 to 3, encoded in the "i2" field.  
For the 64-bit variant: is the immediate index of a quadruplet of four 16-bit elements within each 128-bit vector segment, in the range 0 to 1, encoded in the "i1" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer eltspersegment = 128 DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltspersegment);
    integer s = segmentbase + index;
    bits(esize) res = Elem[operand3, e, esize];
    for i = 0 to 3
        integer element1 = SInt(Elem[operand1, 4 * e + i, esize DIV 4]);
        integer element2 = SInt(Elem[operand2, 4 * s + i, esize DIV 4]);
        res = res + element1 * element2;
    Elem[result, e, esize] = res;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is

UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

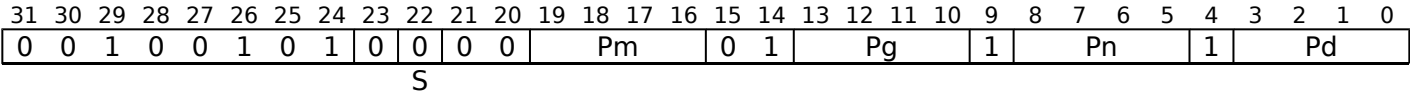
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SEL (predicates)

Conditionally select elements from two predicates

Read active elements from the first source predicate and inactive elements from the second source predicate and place in the corresponding elements of the destination predicate. Does not set the condition flags.

This instruction is used by the alias [MOV \(predicate, predicated, merging\)](#).



SEL <Pd>.B, <Pg>, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
```

Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.
- <Pm> Is the name of the second source scalable predicate register, encoded in the "Pm" field.

Alias Conditions

Alias	Is preferred when
<a href="#">MOV (predicate, predicated, merging)</a>	Pd == Pm

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(PL) operand1 = P[n];
bits(PL) operand2 = P[m];
bits(PL) result;

for e = 0 to elements-1
    bit element1 = ElemP[operand1, e, esize];
    bit element2 = ElemP[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        ElemP[result, e, esize] = element1;
    else
        ElemP[result, e, esize] = element2;

P[d] = result;
```

SEL (vectors)

Conditionally select elements from two vectors

Read active elements from the first source vector and inactive elements from the second source vector and place in the corresponding elements of the destination vector.

This instruction is used by the alias [MOV \(vector, predicated\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	Zm				1	1	Pg			Zn			Zd									

SEL <Zd>.<T>, <Pg>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Alias Conditions

Alias	Is preferred when
<a href="#">MOV (vector, predicated)</a>	Zd == Zm

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) operand2 = if AnyActiveElement(NOT(mask), esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    Elem[result, e, esize] = Elem[operand1, e, esize];
  else
    Elem[result, e, esize] = Elem[operand2, e, esize];

Z[d] = result;
```



# SETFFR

Initialise the first-fault register to all true

Initialise the first-fault register (FFR) to all true prior to a sequence of first-fault or non-fault loads. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	0	1	0	1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

## SETFFR

```
if !HaveSVE() then UNDEFINED;
```

### Operation

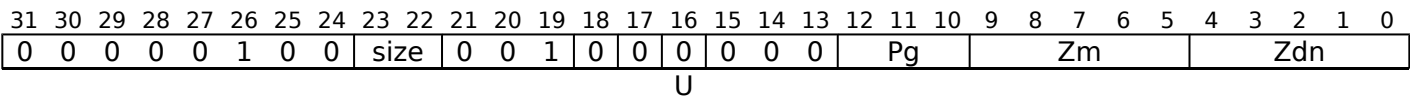
```
CheckSVEEnabled();  
FFR[] = Ones(PL);
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41  
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SMAX (vectors)

Signed maximum vectors (predicated)

Determine the signed maximum of active elements of the second source vector and corresponding elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



SMAX <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean unsigned = FALSE;
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    if ElemP[mask, e, esize] == '1' then
        integer maximum = Max(element1, element2);
        Elem[result, e, esize] = maximum<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

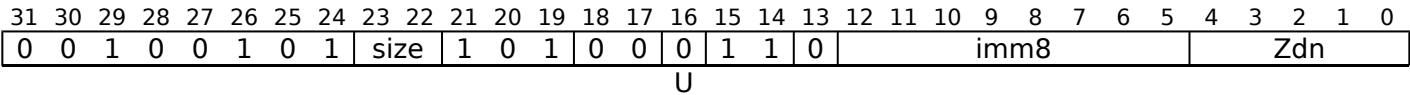
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SMAX (immediate)

Signed maximum with immediate (unpredicated)

Determine the signed maximum of an immediate and each element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate is a signed 8-bit value in the range -128 to +127, inclusive. This instruction is unpredicated.



SMAX <Zdn>.<T>, <Zdn>.<T>, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer dn = UInt(Zdn);
boolean unsigned = FALSE;
integer imm = Int(imm8, unsigned);
```

Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<imm> Is the signed immediate operand, in the range -128 to 127, encoded in the "imm8" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    Elem[result, e, esize] = Max(element1, imm)<esize-1:0>;

Z[dn] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

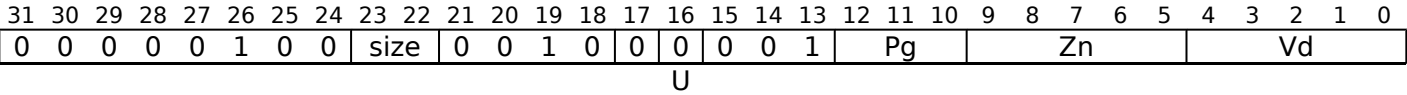
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



SMA XV

Signed maximum reduction to scalar

Signed maximum horizontally across all lanes of a vector, and place the result in the SIMD&FP scalar destination register. Inactive elements in the source vector are treated as the minimum signed integer for the element size.



SMA XV <V><d>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
boolean unsigned = FALSE;
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D

<d> Is the number [0-31] of the destination SIMD&FP register, encoded in the "Vd" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<T> Is the size specifier, encoded in “size”:

size	<T>
00	B
01	H
10	S
11	D

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
integer maximum = if unsigned then 0 else -(2^(esize-1));

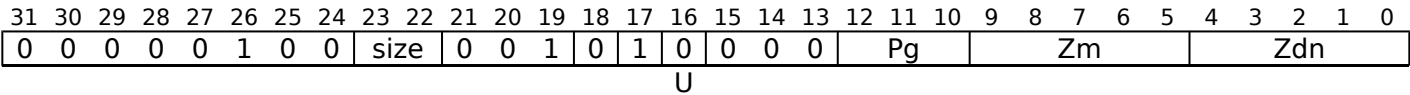
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer element = Int(Elem[operand, e, esize], unsigned);
        maximum = Max(maximum, element);

V[d] = maximum<esize-1:0>;
```

# SMIN (vectors)

Signed minimum vectors (predicated)

Determine the signed minimum of active elements of the second source vector and corresponding elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



SMIN <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean unsigned = FALSE;
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    if ElemP[mask, e, esize] == '1' then
        integer minimum = Min(element1, element2);
        Elem[result, e, esize] = minimum<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

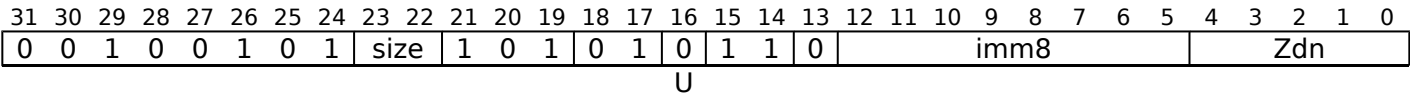
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SMIN (immediate)

Signed minimum with immediate (unpredicated)

Determine the signed minimum of an immediate and each element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate is a signed 8-bit value in the range -128 to +127, inclusive. This instruction is unpredicated.



SMIN <Zdn>.<T>, <Zdn>.<T>, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer dn = UInt(Zdn);
boolean unsigned = FALSE;
integer imm = Int(imm8, unsigned);
```

Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<imm> Is the signed immediate operand, in the range -128 to 127, encoded in the "imm8" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    Elem[result, e, esize] = Min(element1, imm)<esize-1:0>;

Z[dn] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

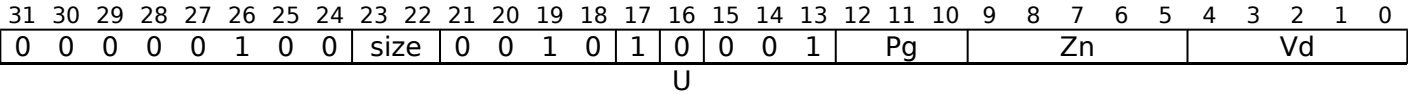
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SMINV

Signed minimum reduction to scalar

Signed minimum horizontally across all lanes of a vector, and place the result in the SIMD&FP scalar destination register. Inactive elements in the source vector are treated as the maximum signed integer for the element size.



SMINV <V><d>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
boolean unsigned = FALSE;
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D

<d> Is the number [0-31] of the destination SIMD&FP register, encoded in the "Vd" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<T> Is the size specifier, encoded in “size”:

size	<T>
00	B
01	H
10	S
11	D

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
integer minimum = if unsigned then (2^esize - 1) else (2^(esize-1) - 1);

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    integer element = Int(Elem[operand, e, esize], unsigned);
    minimum = Min(minimum, element);

V[d] = minimum<esize-1:0>;
```

# SMMLA

Signed integer matrix multiply-accumulate

The signed integer matrix multiply-accumulate instruction multiplies the 2×8 matrix of signed 8-bit integer values held in each 128-bit segment of the first source vector by the 8×2 matrix of signed 8-bit integer values in the corresponding segment of the second source vector. The resulting 2×2 widened 32-bit integer matrix product is then destructively added to the 32-bit integer matrix accumulator held in the corresponding segment of the addend and destination vector. This is equivalent to performing an 8-way dot product per destination element.

This instruction is unpredicated.

ID\_AA64ZFR0\_EL1.I8MM indicates whether this instruction is implemented.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	0	0	0	Zm				1			0	0	1	1	0	Zn				Zda				
uns<1>								uns<0>																							

SMMLA <Zda>.S, <Zn>.B, <Zm>.B

```
if !HaveSVE() || !HaveInt8MatMulExt() then UNDEFINED;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean op1_unsigned = FALSE;
boolean op2_unsigned = FALSE;
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer segments = VL DIV 128;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result = Zeros();
bits(128) op1, op2;
bits(128) res, addend;

for s = 0 to segments-1
    op1 = Elem[operand1, s, 128];
    op2 = Elem[operand2, s, 128];
    addend = Elem[operand3, s, 128];
    res = MatMulAdd(addend, op1, op2, op1_unsigned, op2_unsigned);
    Elem[result, s, 128] = res;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

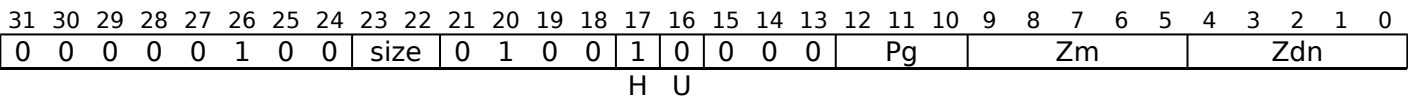
- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



# SMULH

Signed multiply returning high half (predicated)

Widening multiply signed integer values in active elements of the first source vector by corresponding elements of the second source vector and destructively place the high half of the result in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



```
SMULH <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean unsigned = FALSE;
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    if ElemP[mask, e, esize] == '1' then
        integer product = (element1 * element2) >> esize;
        Elem[result, e, esize] = product<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:



- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SPLICE

Splice two vectors under predicate control

Copy the first active to last active elements (inclusive) from the first source vector to the lowest-numbered elements of the result. Then set any remaining elements of the result to a copy of the lowest-numbered elements from the second source vector. The result is placed destructively in the first source vector.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	1	1	0	0	1	0	0		Pg						Zm					Zdn	

**SPLICE** <Zdn>.<T>, <Pg>, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;
integer x = 0;
boolean active = FALSE;
integer lastnum = LastActiveElement(mask, esize);

if lastnum >= 0 then
  for e = 0 to lastnum
    active = active || ElemP[mask, e, esize] == '1';
    if active then
      Elem[result, x, esize] = Elem[operand1, e, esize];
      x = x + 1;

elements = elements - x - 1;
for e = 0 to elements
  Elem[result, x, esize] = Elem[operand2, e, esize];
  x = x + 1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

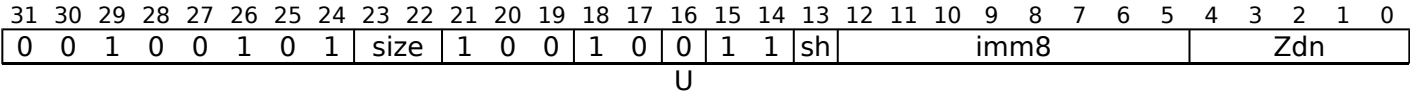
# SQADD (immediate)

Signed saturating add immediate (unpredicated)

Signed saturating add of an unsigned immediate to each element of the source vector, and destructively place the results in the corresponding elements of the source vector. Each result element is saturated to the N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . This instruction is unpredicated.

The immediate is an unsigned value in the range 0 to 255, and for element widths of 16 bits or higher it may also be a positive multiple of 256 in the range 256 to 65280.

The immediate is encoded in 8 bits with an optional left shift by 8. The preferred disassembly when the shift option is specified is "#<uimm8>, LSL #8". However an assembler and disassembler may also allow use of the shifted 16-bit value unless the immediate is 0 and the shift amount is 8, which must be unambiguously described as "#0, LSL #8".



```
SQADD <Zdn>.<T>, <Zdn>.<T>, #<imm>{, <shift>}
```

```
if !HaveSVE() then UNDEFINED;
if size:sh == '001' then UNDEFINED;
integer esize = 8 << UInt(size);
integer dn = UInt(Zdn);
integer imm = UInt(imm8);
if sh == '1' then imm = imm << 8;
boolean unsigned = FALSE;
```

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<imm> Is an unsigned immediate in the range 0 to 255, encoded in the "imm8" field.

<shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #8

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 + imm, esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

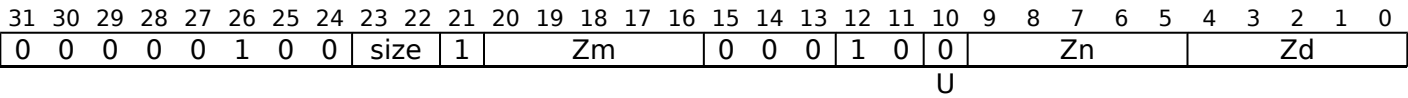
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SQADD (vectors)

Signed saturating add vectors (unpredicated)

Signed saturating add all elements of the second source vector to corresponding elements of the first source vector and place the results in the corresponding elements of the destination vector. Each result element is saturated to the N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . This instruction is unpredicated.



SQADD <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
boolean unsigned = FALSE;
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 + element2, esize, unsigned);

Z[d] = result;
```

# SQDECB

Signed saturating decrement scalar by multiple of 8-bit predicate constraint element count

Determines the number of active 8-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement the scalar destination. The result is saturated to the source general-purpose register's signed integer range. A 32-bit saturated result is then sign-extended to 64 bits.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	1	0	imm4				1	1	1	1	1	0	pattern					Rdn				
size<1>size<0>								sf				D U																			

SQDECB <Xdn>, <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	1	1	imm4				1	1	1	1	1	0	pattern					Rdn				
size<1>size<0>								sf			D U																				

SQDECB <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 64;
```

## Assembler Symbols

- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 - (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# SQDECD (scalar)

Signed saturating decrement scalar by multiple of 64-bit predicate constraint element count

Determines the number of active 64-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement the scalar destination. The result is saturated to the source general-purpose register's signed integer range. A 32-bit saturated result is then sign-extended to 64 bits.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	1	1	0	imm4				1	1	1	1	1	0	pattern					Rdn				
size<1>size<0>								sf								D		U													

SQDECD <Xdn>, <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	1	1	1	imm4				1	1	1	1	1	0	pattern					Rdn				
size<1>size<0>								sf								D		U													

SQDECD <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 64;
```

## Assembler Symbols

- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 - (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SQDECD (vector)

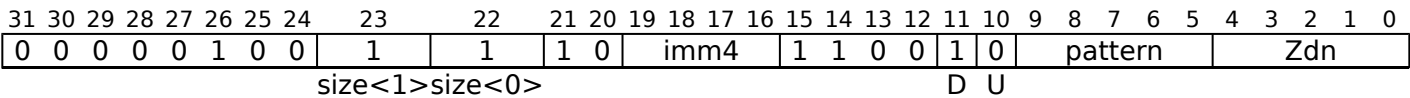
Signed saturating decrement vector by multiple of 64-bit predicate constraint element count

Determines the number of active 64-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement all destination vector elements. The results are saturated to the 64-bit signed integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.



SQDECD <Zdn>.D{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
```

Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer count = DecodePredCount(pat, esize);
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 - (count * imm), esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SQDECH (scalar)

Signed saturating decrement scalar by multiple of 16-bit predicate constraint element count

Determines the number of active 16-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement the scalar destination. The result is saturated to the source general-purpose register's signed integer range. A 32-bit saturated result is then sign-extended to 64 bits.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1	0	imm4				1	1	1	1	1	0	pattern					Rdn				
size<1>size<0>								sf									D		U												

SQDECH <Xdn>, <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1	1	imm4				1	1	1	1	1	0	pattern					Rdn				
size<1>size<0>								sf									D		U												

SQDECH <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 64;
```

## Assembler Symbols

- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 - (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SQDECH (vector)

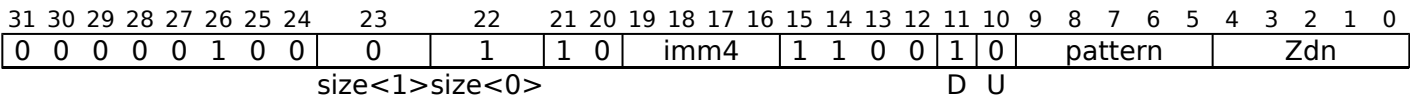
Signed saturating decrement vector by multiple of 16-bit predicate constraint element count

Determines the number of active 16-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement all destination vector elements. The results are saturated to the 16-bit signed integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.



SQDECH <Zdn>.H{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
```

Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer count = DecodePredCount(pat, esize);
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 - (count * imm), esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



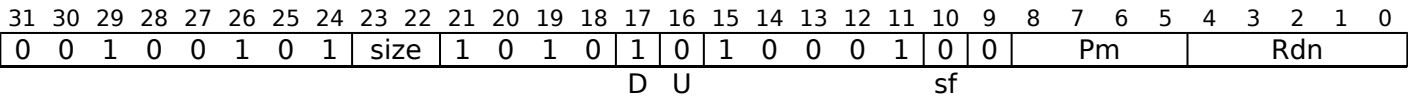
# SQDECP (scalar)

Signed saturating decrement scalar by count of true predicate elements

Counts the number of true elements in the source predicate and then uses the result to decrement the scalar destination. The result is saturated to the source general-purpose register's signed integer range. A 32-bit saturated result is then sign-extended to 64 bits.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

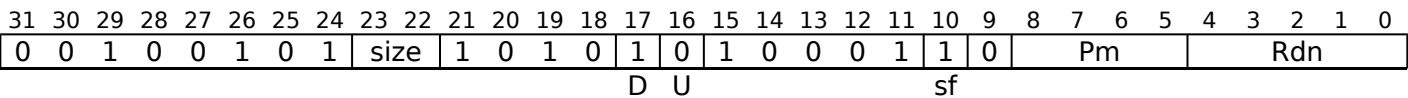
## 32-bit



SQDECP <Xdn>, <Pm>.<T>, <Wdn>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Rdn);
boolean unsigned = FALSE;
integer ssize = 32;
```

## 64-bit



SQDECP <Xdn>, <Pm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Rdn);
boolean unsigned = FALSE;
integer ssize = 64;
```

## Assembler Symbols

- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Pm> Is the name of the source scalable predicate register, encoded in the "Pm" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(ssize) operand1 = X[dn];
bits(PL) operand2 = P[m];
bits(ssize) result;
integer count = 0;

for e = 0 to elements-1
    if ElemP[operand2, e, esize] == '1' then
        count = count + 1;

integer element = Int(operand1, unsigned);
(result, -) = Sat0(element - count, ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);
```

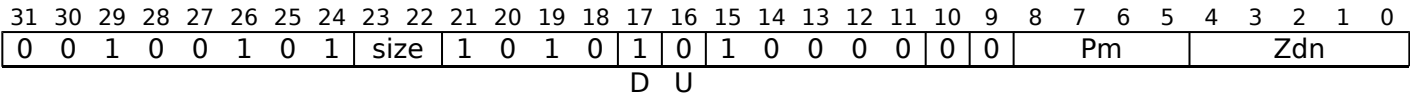
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SQDECP (vector)

Signed saturating decrement vector by count of true predicate elements

Counts the number of true elements in the source predicate and then uses the result to decrement all destination vector elements. The results are saturated to the element signed integer range.  
The predicate size specifier may be omitted in assembler source code, but this is deprecated and will be prohibited in a future release of the architecture.



SQDECP <Zdn>.<T>, <Pm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Zdn);
boolean unsigned = FALSE;
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pm> Is the name of the source scalable predicate register, encoded in the "Pm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(PL) operand2 = P[m];
bits(VL) result;
integer count = 0;

for e = 0 to elements-1
    if ElemP[operand2, e, esize] == '1' then
        count = count + 1;

for e = 0 to elements-1
    integer element = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element - count, esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SQDECW (scalar)

Signed saturating decrement scalar by multiple of 32-bit predicate constraint element count

Determines the number of active 32-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement the scalar destination. The result is saturated to the source general-purpose register's signed integer range. A 32-bit saturated result is then sign-extended to 64 bits.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	0	1	0	imm4				1	1	1	1	1	0	pattern					Rdn				
size<1>size<0>								sf		D U																					

SQDECW <Xdn>, <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	0	1	1	imm4				1	1	1	1	1	0	pattern					Rdn				
size<1>size<0>								sf		D U																					

SQDECW <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 64;
```

## Assembler Symbols

- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 - (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SQDECW (vector)

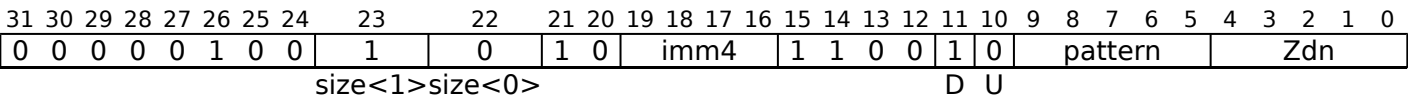
Signed saturating decrement vector by multiple of 32-bit predicate constraint element count

Determines the number of active 32-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement all destination vector elements. The results are saturated to the 32-bit signed integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.



SQDECW <Zdn>.S{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
```

Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer count = DecodePredCount(pat, esize);
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 - (count * imm), esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# SQINCB

Signed saturating increment scalar by multiple of 8-bit predicate constraint element count

Determines the number of active 8-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment the scalar destination. The result is saturated to the source general-purpose register's signed integer range. A 32-bit saturated result is then sign-extended to 64 bits.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	1	0	imm4				1	1	1	1	0	0	pattern					Rdn				
size<1>size<0>								sf			D U																				

SQINCB <Xdn>, <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	1	1	imm4				1	1	1	1	0	0	pattern					Rdn				
size<1>size<0>								sf			D U																				

SQINCB <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 64;
```

## Assembler Symbols

- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 + (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SQINCD (scalar)

Signed saturating increment scalar by multiple of 64-bit predicate constraint element count

Determines the number of active 64-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment the scalar destination. The result is saturated to the source general-purpose register's signed integer range. A 32-bit saturated result is then sign-extended to 64 bits.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	1	1	0	imm4				1	1	1	1	0	0	pattern					Rdn				
size<1>size<0>								sf									D		U												

SQINCD <Xdn>, <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	1	1	1	imm4				1	1	1	1	0	0	pattern					Rdn				
size<1>size<0>								sf									D		U												

SQINCD <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 64;
```

## Assembler Symbols

- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 + (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SQINCD (vector)

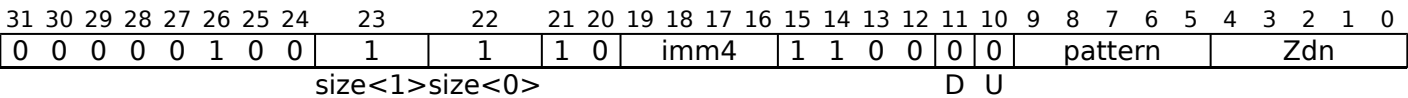
Signed saturating increment vector by multiple of 64-bit predicate constraint element count

Determines the number of active 64-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment all destination vector elements. The results are saturated to the 64-bit signed integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.



SQINCD <Zdn>.D{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
```

Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer count = DecodePredCount(pat, esize);
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 + (count * imm), esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SQINCH (scalar)

Signed saturating increment scalar by multiple of 16-bit predicate constraint element count

Determines the number of active 16-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment the scalar destination. The result is saturated to the source general-purpose register's signed integer range. A 32-bit saturated result is then sign-extended to 64 bits.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1	0	imm4				1	1	1	1	0	0	pattern					Rdn				
size<1>size<0>								sf									D		U												

SQINCH <Xdn>, <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1	1	imm4				1	1	1	1	0	0	pattern					Rdn				
size<1>size<0>								sf									D		U												

SQINCH <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 64;
```

## Assembler Symbols

- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 + (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



SQINCH (vector)

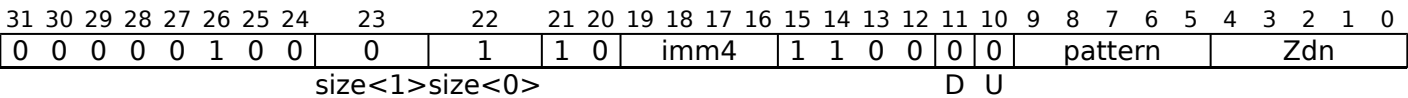
Signed saturating increment vector by multiple of 16-bit predicate constraint element count

Determines the number of active 16-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment all destination vector elements. The results are saturated to the 16-bit signed integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.



SQINCH <Zdn>.H{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
```

Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer count = DecodePredCount(pat, esize);
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 + (count * imm), esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SQINCP (scalar)

Signed saturating increment scalar by count of true predicate elements

Counts the number of true elements in the source predicate and then uses the result to increment the scalar destination. The result is saturated to the source general-purpose register's signed integer range. A 32-bit saturated result is then sign-extended to 64 bits.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	0	1	0	0	0	1	0	0	0	1	0	0	Pm	Rdn								
D U														sf																	

SQINCP <Xdn>, <Pm>.<T>, <Wdn>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Rdn);
boolean unsigned = FALSE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	0	1	0	0	0	1	0	0	0	1	1	0	Pm			Rdn						
D U														sf																	

SQINCP <Xdn>, <Pm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Rdn);
boolean unsigned = FALSE;
integer ssize = 64;
```

## Assembler Symbols

- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Pm> Is the name of the source scalable predicate register, encoded in the "Pm" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(ssize) operand1 = X[dn];
bits(PL) operand2 = P[m];
bits(ssize) result;
integer count = 0;

for e = 0 to elements-1
    if ElemP[operand2, e, esize] == '1' then
        count = count + 1;

integer element = Int(operand1, unsigned);
(result, -) = Sat0(element + count, ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);
```

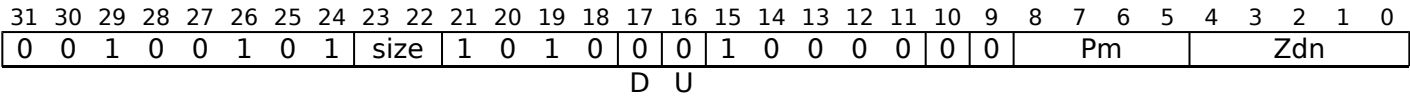
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SQINCP (vector)

Signed saturating increment vector by count of true predicate elements

Counts the number of true elements in the source predicate and then uses the result to increment all destination vector elements. The results are saturated to the element signed integer range. The predicate size specifier may be omitted in assembler source code, but this is deprecated and will be prohibited in a future release of the architecture.



SQINCP <Zdn>.<T>, <Pm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Zdn);
boolean unsigned = FALSE;
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pm> Is the name of the source scalable predicate register, encoded in the "Pm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(PL) operand2 = P[m];
bits(VL) result;
integer count = 0;

for e = 0 to elements-1
    if ElemP[operand2, e, esize] == '1' then
        count = count + 1;

for e = 0 to elements-1
    integer element = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element + count, esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SQINCW (scalar)

Signed saturating increment scalar by multiple of 32-bit predicate constraint element count

Determines the number of active 32-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment the scalar destination. The result is saturated to the source general-purpose register's signed integer range. A 32-bit saturated result is then sign-extended to 64 bits.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	0	1	0	imm4				1	1	1	1	0	0	pattern					Rdn				
size<1>size<0>								sf			D U																				

SQINCW <Xdn>, <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	0	1	1	imm4				1	1	1	1	0	0	pattern					Rdn				
size<1>size<0>								sf			D U																				

SQINCW <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 64;
```

## Assembler Symbols

- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 + (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



# SQINCW (vector)

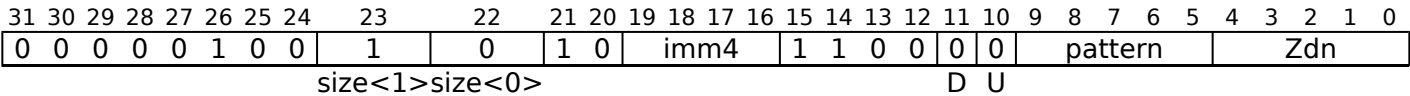
Signed saturating increment vector by multiple of 32-bit predicate constraint element count

Determines the number of active 32-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment all destination vector elements. The results are saturated to the 32-bit signed integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.



SQINCW <Zdn>.S{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer count = DecodePredCount(pat, esize);
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 + (count * imm), esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

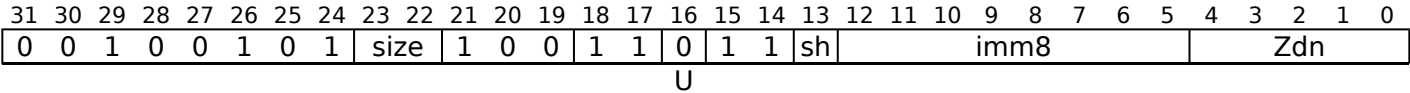
# SQSUB (immediate)

Signed saturating subtract immediate (unpredicated)

Signed saturating subtract of an unsigned immediate from each element of the source vector, and destructively place the results in the corresponding elements of the source vector. Each result element is saturated to the N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . This instruction is unpredicated.

The immediate is an unsigned value in the range 0 to 255, and for element widths of 16 bits or higher it may also be a positive multiple of 256 in the range 256 to 65280.

The immediate is encoded in 8 bits with an optional left shift by 8. The preferred disassembly when the shift option is specified is "#<uimm8>, LSL #8". However an assembler and disassembler may also allow use of the shifted 16-bit value unless the immediate is 0 and the shift amount is 8, which must be unambiguously described as "#0, LSL #8".



SQSUB <Zdn>.<T>, <Zdn>.<T>, #<imm>{, <shift>}

```
if !HaveSVE() then UNDEFINED;
if size:sh == '001' then UNDEFINED;
integer esize = 8 << UInt(size);
integer dn = UInt(Zdn);
integer imm = UInt(imm8);
if sh == '1' then imm = imm << 8;
boolean unsigned = FALSE;
```

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<imm> Is an unsigned immediate in the range 0 to 255, encoded in the "imm8" field.

<shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #8

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 - imm, esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

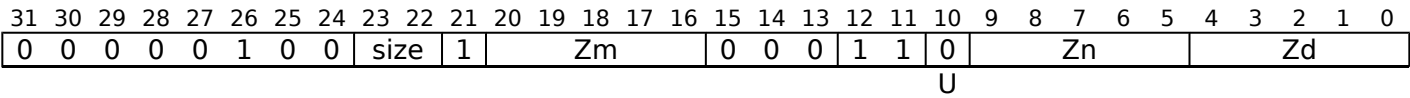
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

SQSUB (vectors)

Signed saturating subtract vectors (unpredicated)

Signed saturating subtract all elements of the second source vector from corresponding elements of the first source vector and place the results in the corresponding elements of the destination vector. Each result element is saturated to the N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . This instruction is unpredicated.



SQSUB <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
boolean unsigned = FALSE;
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 - element2, esize, unsigned);

Z[d] = result;
```

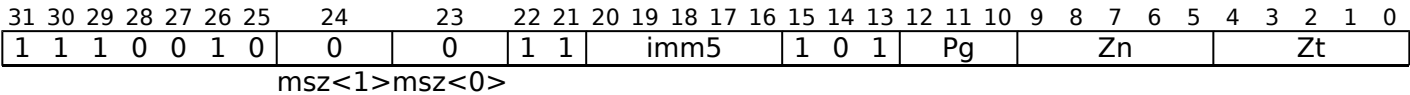
## ST1B (vector plus immediate)

Scatter store bytes from a vector (immediate index)

Scatter store of bytes from the active elements of a vector register to the memory addresses generated by a vector base plus immediate index. The index is in the range 0 to 31. Inactive elements are not written to memory.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

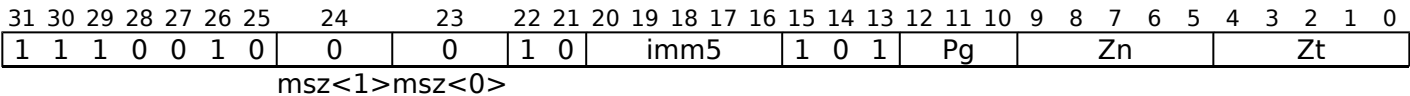
### 32-bit element



ST1B { <Zt>.S }, <Pg>, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
integer offset = UInt(imm5);
```

### 64-bit element



ST1B { <Zt>.D }, <Pg>, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
integer offset = UInt(imm5);
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, in the range 0 to 31, defaulting to 0, encoded in the "imm5" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) base;
bits(VL) src;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if AnyActiveElement(mask, esize) then
    base = Z[n];
    src = Z[t];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
```

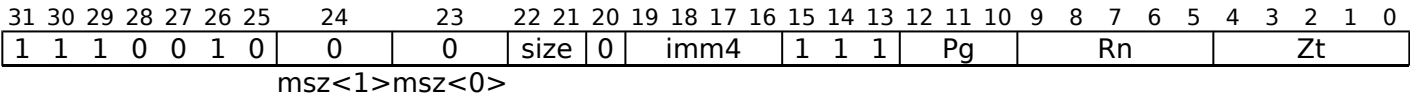
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# ST1B (scalar plus immediate)

Contiguous store bytes from vector (immediate index)

Contiguous store of bytes from elements of a vector register to the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements are not written to memory.



ST1B { <Zt>.<T> }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8 << UInt(size);
integer msize = 8;
integer offset = SInt(imm4);
```

## Assembler Symbols

<Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

<imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) src;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        src = Z[t];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + eoff * mbytes;
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
```





# ST1B (scalar plus scalar)

Contiguous store bytes from vector (scalar index)

Contiguous store of bytes from elements of a vector register to the memory address generated by a 64-bit scalar base and scalar index which is added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements are not written to memory.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	0	0	size	Rm						0	1	0	Pg			Rn				Zt					

ST1B { <Zt>.<T> }, <Pg>, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 8 << UInt(size);
integer msize = 8;
```

## Assembler Symbols

<Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

<Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(64) offset;
bits(VL) src;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];
    src = Z[t];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = base + (UInt(offset) + e) * mbytes;
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
```



## ST1B (scalar plus vector)

Scatter store bytes from a vector (vector index)

Scatter store of bytes from the active elements of a vector register to the memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally sign or zero-extended from 32 to 64 bits. Inactive elements are not written to memory.

It has encodings from 3 classes: [32-bit unpacked unscaled offset](#) , [32-bit unscaled offset](#) and [64-bit unscaled offset](#)

### 32-bit unpacked unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	0	0	0	0	Zm			1	xs	0	Pg			Rn			Zt								
msz<1>msz<0>																															

ST1B { <Zt>.D }, <Pg>, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
integer offs_size = 32;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

### 32-bit unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	0	0	1	0	Zm	1	xs	0	Pg	Rn	Zt														
msz<1>msz<0>																															

ST1B { <Zt>.S }, <Pg>, [<Xn|SP>, <Zm>.S, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
integer offs_size = 32;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

### 64-bit unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	0	0	0	0	Zm	1	0	1	Pg	Rn	Zt														
msz<1>msz<0>																															

ST1B { <Zt>.D }, <Pg>, [<Xn|SP>, <Zm>.D]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
integer offs_size = 64;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) offset;
bits(VL) src;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

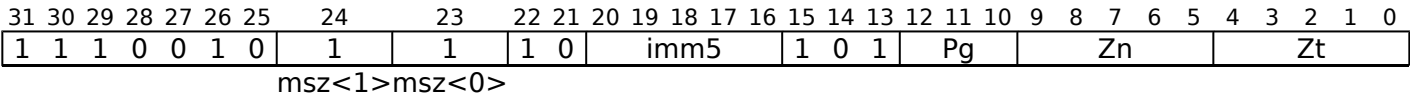
if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = Z[m];
    src = Z[t];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        bits(64) addr = base + (off << scale);
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
```

# ST1D (vector plus immediate)

Scatter store doublewords from a vector (immediate index)

Scatter store of doublewords from the active elements of a vector register to the memory addresses generated by a vector base plus immediate index. The index is a multiple of 8 in the range 0 to 248. Inactive elements are not written to memory.



ST1D { <Zt>.D }, <Pg>, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
integer offset = UInt(imm5);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 8 in the range 0 to 248, defaulting to 0, encoded in the "imm5" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) base;
bits(VL) src;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

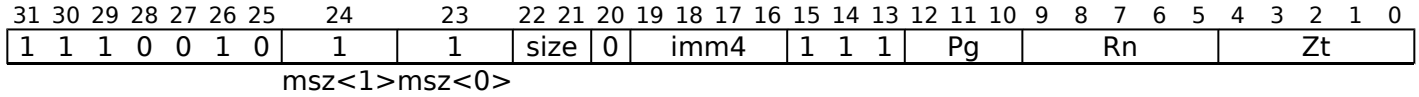
if AnyActiveElement(mask, esize) then
    base = Z[n];
    src = Z[t];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
```

## ST1D (scalar plus immediate)

Contiguous store doublewords from vector (immediate index)

Contiguous store of doublewords from elements of a vector register to the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements are not written to memory.



**ST1D { <Zt>.D }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]**

```
if !HaveSVE() then UNDEFINED;
if size != '11' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8 << UInt(size);
integer msize = 64;
integer offset = SInt(imm4);
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) src;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    src = Z[t];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + eoff * mbytes;
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## ST1D (scalar plus scalar)

Contiguous store doublewords from vector (scalar index)

Contiguous store of doublewords from elements of a vector register to the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 8 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements are not written to memory.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	1	1	1	1	Rm				0	1	0	Pg				Rn				Zt					

**ST1D { <Zt>.D }, <Pg>, [<Xn|SP>, <Xm>, LSL #3]**

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(64) offset;
bits(VL) src;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = X[m];
        src = Z[t];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = base + (UInt(offset) + e) * mbytes;
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



## ST1D (scalar plus vector)

Scatter store doublewords from a vector (vector index)

Scatter store of doublewords from the active elements of a vector register to the memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then optionally multiplied by 8. Inactive elements are not written to memory.

It has encodings from 4 classes: [32-bit unpacked scaled offset](#) , [32-bit unpacked unscaled offset](#) , [64-bit scaled offset](#) and [64-bit unscaled offset](#)

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	1	1	0	1	Zm				1	xs	0	Pg			Rn				Zt						
							msz<1>		msz<0>																						

ST1D { <Zt>.D }, <Pg>, [<Xn|SP>, <Zm>.D, <mod> #3]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
integer offs_size = 32;
boolean offs_unsigned = xs == '0';
integer scale = 3;
```

### 32-bit unpacked unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	1	1	0	0	Zm				1	xs	0	Pg			Rn				Zt						
							msz<1>		msz<0>																						

ST1D { <Zt>.D }, <Pg>, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
integer offs_size = 32;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

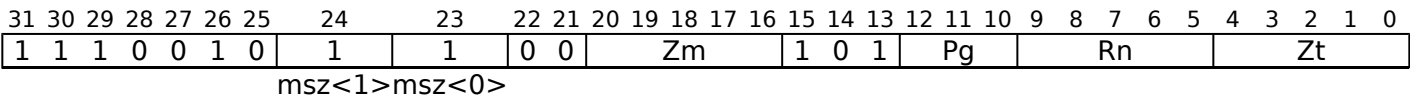
### 64-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	1	1	0	1	Zm				1	0	1	Pg			Rn				Zt						
							msz<1>		msz<0>																						

ST1D { <Zt>.D }, <Pg>, [<Xn|SP>, <Zm>.D, LSL #3]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
integer offs_size = 64;
boolean offs_unsigned = TRUE;
integer scale = 3;
```

64-bit unscaled offset



ST1D { <Zt>.D }, <Pg>, [<Xn|SP>, <Zm>.D]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
integer offs_size = 64;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) offset;
bits(VL) src;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = Z[m];
        src = Z[t];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        bits(64) addr = base + (off << scale);
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

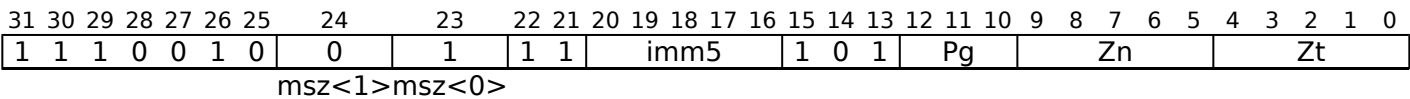
# ST1H (vector plus immediate)

Scatter store halfwords from a vector (immediate index)

Scatter store of halfwords from the active elements of a vector register to the memory addresses generated by a vector base plus immediate index. The index is a multiple of 2 in the range 0 to 62. Inactive elements are not written to memory.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

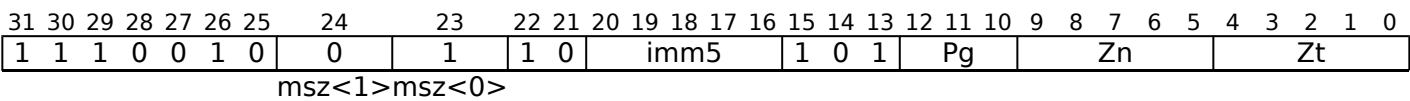
## 32-bit element



ST1H { <Zt>.S }, <Pg>, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
integer offset = UInt(imm5);
```

## 64-bit element



ST1H { <Zt>.D }, <Pg>, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offset = UInt(imm5);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 2 in the range 0 to 62, defaulting to 0, encoded in the "imm5" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) base;
bits(VL) src;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if AnyActiveElement(mask, esize) then
    base = Z[n];
    src = Z[t];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
```

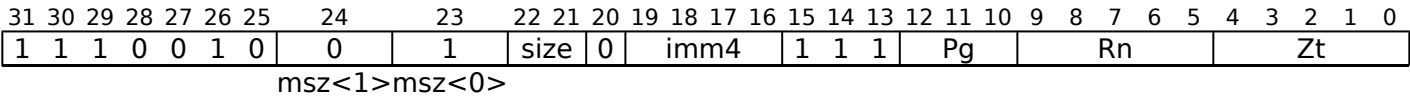
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

ST1H (scalar plus immediate)

Contiguous store halfwords from vector (immediate index)

Contiguous store of halfwords from elements of a vector register to the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements are not written to memory.



ST1H { <Zt>.<T> }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8 << UInt(size);
integer msize = 16;
integer offset = SInt(imm4);
```

Assembler Symbols

<Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

<imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) src;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    src = Z[t];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + eoff * mbytes;
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

ST1H (scalar plus scalar)

Contiguous store halfwords from vector (scalar index)

Contiguous store of halfwords from elements of a vector register to the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 2 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements are not written to memory.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	0	1	size			Rm				0	1	0	Pg			Rn				Zt					

ST1H { <Zt>.<T> }, <Pg>, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 8 << UInt(size);
integer msize = 16;
```

Assembler Symbols

<Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

<Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) mask = P[g];
bits(64) offset;
bits(VL) src;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = X[m];
        src = Z[t];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = base + (UInt(offset) + e) * mbytes;
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## ST1H (scalar plus vector)

Scatter store halfwords from a vector (vector index)

Scatter store of halfwords from the active elements of a vector register to the memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then optionally multiplied by 2. Inactive elements are not written to memory.

It has encodings from 6 classes: [32-bit scaled offset](#) , [32-bit unpacked scaled offset](#) , [32-bit unpacked unscaled offset](#) , [32-bit unscaled offset](#) , [64-bit scaled offset](#) and [64-bit unscaled offset](#)

### 32-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	0	1	1	Zm			1	xs	0	Pg			Rn			Zt									
msz<1>msz<0>																															

ST1H { <Zt>.S }, <Pg>, [<Xn|SP>, <Zm>.S, <mod> #1]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
integer offs_size = 32;
boolean offs_unsigned = xs == '0';
integer scale = 1;
```

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	0	1	0	1	Zm	1	xs	0	Pg	Rn	Zt														
msz<1>msz<0>																															

ST1H { <Zt>.D }, <Pg>, [<Xn|SP>, <Zm>.D, <mod> #1]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 32;
boolean offs_unsigned = xs == '0';
integer scale = 1;
```

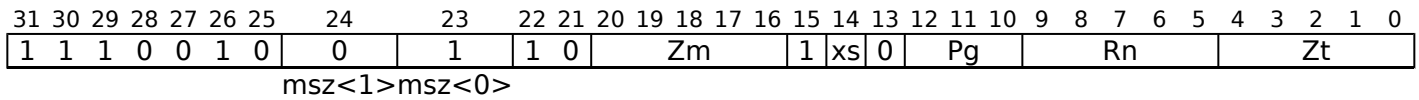
### 32-bit unpacked unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	0	1	0	0	Zm	1	xs	0	Pg	Rn	Zt														
msz<1>msz<0>																															

ST1H { <Zt>.D }, <Pg>, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 32;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

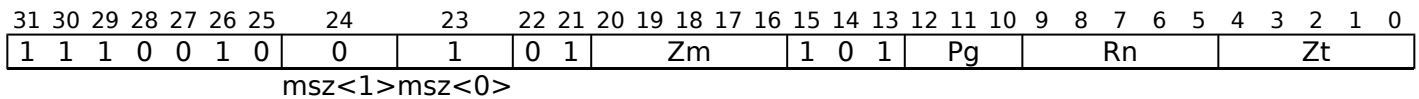
### 32-bit unscaled offset



ST1H { <Zt>.S }, <Pg>, [<Xn|SP>, <Zm>.S, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
integer offs_size = 32;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

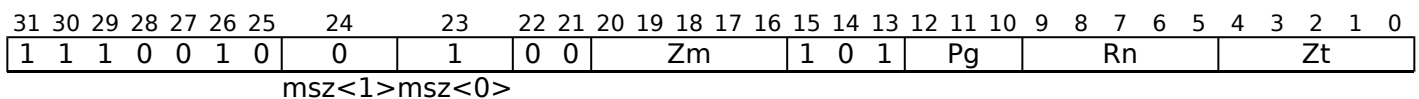
### 64-bit scaled offset



ST1H { <Zt>.D }, <Pg>, [<Xn|SP>, <Zm>.D, LSL #1]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 64;
boolean offs_unsigned = TRUE;
integer scale = 1;
```

### 64-bit unscaled offset



ST1H { <Zt>.D }, <Pg>, [<Xn|SP>, <Zm>.D]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 64;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) offset;
bits(VL) src;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = Z[m];
    src = Z[t];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        bits(64) addr = base + (off << scale);
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
```

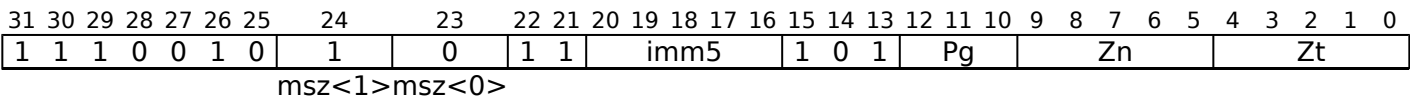
# ST1W (vector plus immediate)

Scatter store words from a vector (immediate index)

Scatter store of words from the active elements of a vector register to the memory addresses generated by a vector base plus immediate index. The index is a multiple of 4 in the range 0 to 124. Inactive elements are not written to memory.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

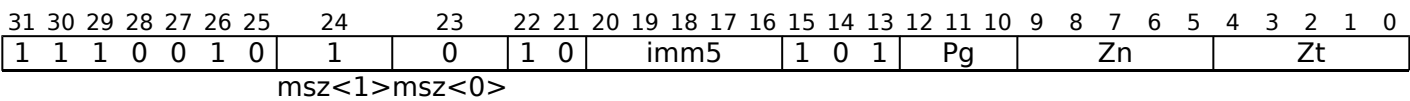
## 32-bit element



ST1W { <Zt>.S }, <Pg>, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 32;
integer offset = UInt(imm5);
```

## 64-bit element



ST1W { <Zt>.D }, <Pg>, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offset = UInt(imm5);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 4 in the range 0 to 124, defaulting to 0, encoded in the "imm5" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) base;
bits(VL) src;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if AnyActiveElement(mask, esize) then
    base = Z[n];
    src = Z[t];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
```

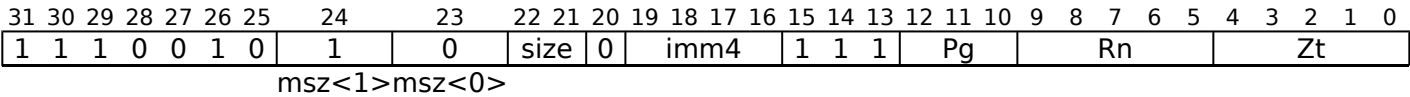
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# ST1W (scalar plus immediate)

Contiguous store words from vector (immediate index)

Contiguous store of words from elements of a vector register to the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements are not written to memory.



ST1W { <Zt>.<T> }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
if size != '1x' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8 << UInt(size);
integer msize = 32;
integer offset = SInt(imm4);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <T> Is the size specifier, encoded in "size<0>":

size<0>	<T>
0	S
1	D
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) src;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    src = Z[t];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + eoff * mbytes;
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
```





# ST1W (scalar plus scalar)

Contiguous store words from vector (scalar index)

Contiguous store of words from elements of a vector register to the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 4 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements are not written to memory.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	1	0	size			Rm				0	1	0	Pg			Rn				Zt					

ST1W { <Zt>.<T> }, <Pg>, [<Xn|SP>, <Xm>, LSL #2]

```
if !HaveSVE() then UNDEFINED;
if size != '1x' then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 8 << UInt(size);
integer msize = 32;
```

## Assembler Symbols

- <Zt>

Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <T>

Is the size specifier, encoded in "size<0>":

size<0>	<T>
0	S
1	D
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP>

Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm>

Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(64) offset;
bits(VL) src;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = X[m];
        src = Z[t];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = base + (UInt(offset) + e) * mbytes;
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
```



## ST1W (scalar plus vector)

Scatter store words from a vector (vector index)

Scatter store of words from the active elements of a vector register to the memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then optionally multiplied by 4. Inactive elements are not written to memory.

It has encodings from 6 classes: [32-bit scaled offset](#) , [32-bit unpacked scaled offset](#) , [32-bit unpacked unscaled offset](#) , [32-bit unscaled offset](#) , [64-bit scaled offset](#) and [64-bit unscaled offset](#)

### 32-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	1	0	1	1	Zm				1	xs	0	Pg			Rn				Zt						
							msz<1>		msz<0>																						

ST1W { <Zt>.S }, <Pg>, [<Xn|SP>, <Zm>.S, <mod> #2]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 32;
integer offs_size = 32;
boolean offs_unsigned = xs == '0';
integer scale = 2;
```

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	1	0	0	1	Zm				1	xs	0	Pg			Rn				Zt						
							msz<1>		msz<0>																						

ST1W { <Zt>.D }, <Pg>, [<Xn|SP>, <Zm>.D, <mod> #2]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 32;
boolean offs_unsigned = xs == '0';
integer scale = 2;
```

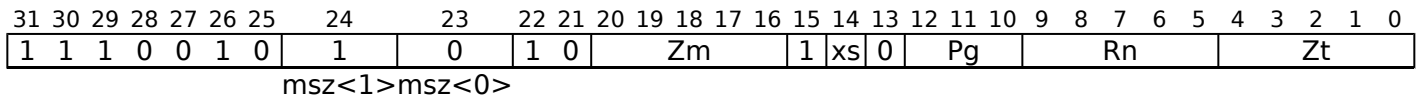
### 32-bit unpacked unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	1	0	0	0	Zm				1	xs	0	Pg			Rn				Zt						
							msz<1>		msz<0>																						

ST1W { <Zt>.D }, <Pg>, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 32;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

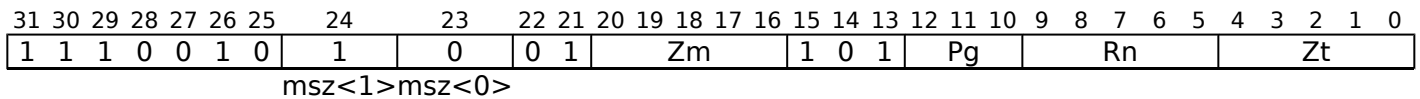
### 32-bit unscaled offset



ST1W { <Zt>.S }, <Pg>, [<Xn|SP>, <Zm>.S, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 32;
integer offs_size = 32;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

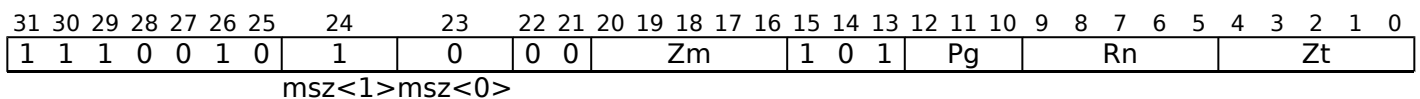
### 64-bit scaled offset



ST1W { <Zt>.D }, <Pg>, [<Xn|SP>, <Zm>.D, LSL #2]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 64;
boolean offs_unsigned = TRUE;
integer scale = 2;
```

### 64-bit unscaled offset



ST1W { <Zt>.D }, <Pg>, [<Xn|SP>, <Zm>.D]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 64;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(VL) offset;
bits(VL) src;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = Z[m];
    src = Z[t];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        bits(64) addr = base + (off << scale);
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
```

## ST2B (scalar plus immediate)

Contiguous store two-byte structures from two vectors (immediate index)

Contiguous store two-byte structures, each from the same element number in two vector registers to the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 2 in the range -16 to 14 that is multiplied by the vector's in-memory size, irrespective of predication,

Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive bytes in memory which make up each structure. Inactive structures are not written to memory.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	0	0	0	1	1	imm4			1	1	1	Pg			Rn			Zt							
msz<1>msz<0>																															

ST2B { <Zt1>.B, <Zt2>.B }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8;
integer offset = SInt(imm4);
integer nreg = 2;
```

### Assembler Symbols

<Zt1>	Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
<Zt2>	Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<imm>	Is the optional signed immediate vector offset, a multiple of 2 in the range -16 to 14, defaulting to 0, encoded in the "imm4" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = (offset * elements * nreg) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
```



## ST2B (scalar plus scalar)

Contiguous store two-byte structures from two vectors (scalar index)

Contiguous store two-byte structures, each from the same element number in two vector registers to the memory address generated by a 64-bit scalar base and a 64-bit scalar index register and added to the base address. After each structure access the index value is incremented by two. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive bytes in memory which make up each structure. Inactive structures are not written to memory.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	0	0	0	1	Rm				0	1	1	Pg			Rn				Zt						
msz<1>msz<0>																															

ST2B { <Zt1>.B, <Zt2>.B }, <Pg>, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 8;
integer nreg = 2;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(64) offset;
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = X[m];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = UInt(offset) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
```



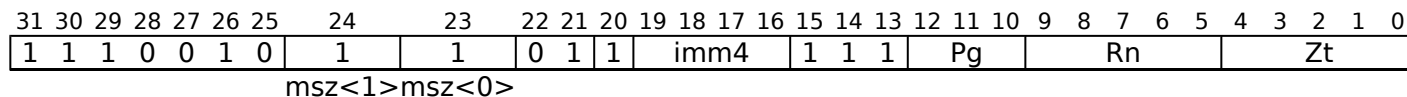


## ST2D (scalar plus immediate)

Contiguous store two-doubleword structures from two vectors (immediate index)

Contiguous store two-doubleword structures, each from the same element number in two vector registers to the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 2 in the range -16 to 14 that is multiplied by the vector's in-memory size, irrespective of predication,

Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive doublewords in memory which make up each structure. Inactive structures are not written to memory.



ST2D { <Zt1>.D, <Zt2>.D }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer offset = SInt(imm4);
integer nreg = 2;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 2 in the range -16 to 14, defaulting to 0, encoded in the "imm4" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = (offset * elements * nreg) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
```

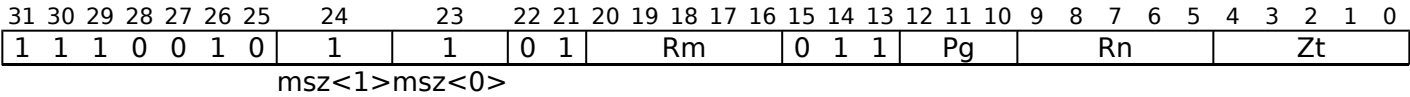


## ST2D (scalar plus scalar)

Contiguous store two-doubleword structures from two vectors (scalar index)

Contiguous store two-doubleword structures, each from the same element number in two vector registers to the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by two. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive doublewords in memory which make up each structure. Inactive structures are not written to memory.



ST2D { <Zt1>.D, <Zt2>.D }, <Pg>, [<Xn|SP>, <Xm>, LSL #3]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer nreg = 2;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(64) offset;
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = UInt(offset) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## ST2H (scalar plus immediate)

Contiguous store two-halfword structures from two vectors (immediate index)

Contiguous store two-halfword structures, each from the same element number in two vector registers to the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 2 in the range -16 to 14 that is multiplied by the vector's in-memory size, irrespective of predication,

Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive halfwords in memory which make up each structure. Inactive structures are not written to memory.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	0	1	0	1	1	imm4			1	1	1	Pg			Rn			Zt							
msz<1>msz<0>																															

ST2H { <Zt1>.H, <Zt2>.H }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer offset = SInt(imm4);
integer nreg = 2;
```

### Assembler Symbols

<Zt1>	Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
<Zt2>	Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<imm>	Is the optional signed immediate vector offset, a multiple of 2 in the range -16 to 14, defaulting to 0, encoded in the "imm4" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = (offset * elements * nreg) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
```

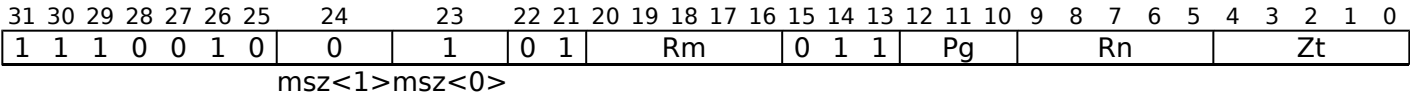


## ST2H (scalar plus scalar)

Contiguous store two-halfword structures from two vectors (scalar index)

Contiguous store two-halfword structures, each from the same element number in two vector registers to the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by two. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive halfwords in memory which make up each structure. Inactive structures are not written to memory.



ST2H { <Zt1>.H, <Zt2>.H }, <Pg>, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
integer nreg = 2;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(64) offset;
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = UInt(offset) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## ST2W (scalar plus immediate)

Contiguous store two-word structures from two vectors (immediate index)

Contiguous store two-word structures, each from the same element number in two vector registers to the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 2 in the range -16 to 14 that is multiplied by the vector's in-memory size, irrespective of predication,

Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive words in memory which make up each structure. Inactive structures are not written to memory.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	1	0	0	1	1	imm4			1	1	1	Pg			Rn			Zt							
msz<1>msz<0>																															

ST2W { <Zt1>.S, <Zt2>.S }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer offset = SInt(imm4);
integer nreg = 2;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 2 in the range -16 to 14, defaulting to 0, encoded in the "imm4" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = (offset * elements * nreg) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
```

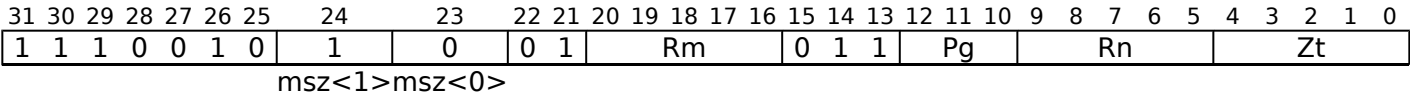


## ST2W (scalar plus scalar)

Contiguous store two-word structures from two vectors (scalar index)

Contiguous store two-word structures, each from the same element number in two vector registers to the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by two. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive words in memory which make up each structure. Inactive structures are not written to memory.



ST2W { <Zt1>.S, <Zt2>.S }, <Pg>, [<Xn|SP>, <Xm>, LSL #2]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer nreg = 2;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(64) offset;
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = UInt(offset) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

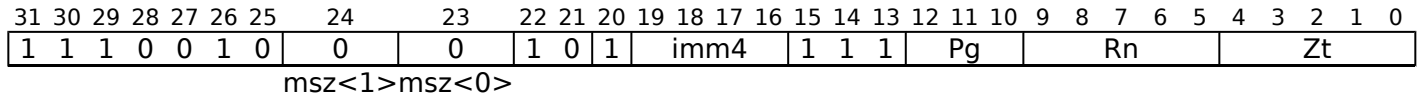
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## ST3B (scalar plus immediate)

Contiguous store three-byte structures from three vectors (immediate index)

Contiguous store three-byte structures, each from the same element number in three vector registers to the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 3 in the range -24 to 21 that is multiplied by the vector's in-memory size, irrespective of predication,

Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive bytes in memory which make up each structure. Inactive structures are not written to memory.



ST3B { <Zt1>.B, <Zt2>.B, <Zt3>.B }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8;
integer offset = SInt(imm4);
integer nreg = 3;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 3 in the range -24 to 21, defaulting to 0, encoded in the "imm4" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

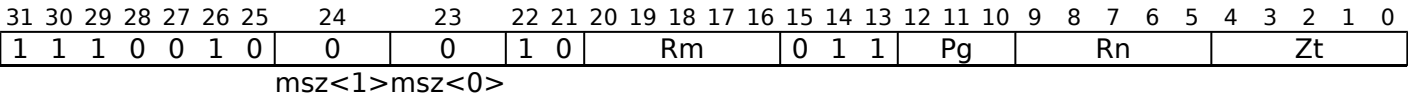
for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = (offset * elements * nreg) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
```



## ST3B (scalar plus scalar)

Contiguous store three-byte structures from three vectors (scalar index)

Contiguous store three-byte structures, each from the same element number in three vector registers to the memory address generated by a 64-bit scalar base and a 64-bit scalar index register and added to the base address. After each structure access the index value is incremented by three. The index register is not updated by the instruction. Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive bytes in memory which make up each structure. Inactive structures are not written to memory.



ST3B { <Zt1>.B, <Zt2>.B, <Zt3>.B }, <Pg>, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 8;
integer nreg = 3;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(64) offset;
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = UInt(offset) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
```

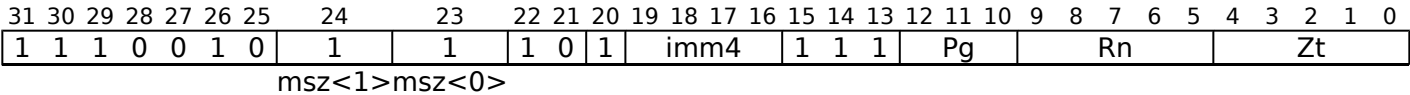
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

ST3D (scalar plus immediate)

Contiguous store three-doubleword structures from three vectors (immediate index)

Contiguous store three-doubleword structures, each from the same element number in three vector registers to the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 3 in the range -24 to 21 that is multiplied by the vector's in-memory size, irrespective of predication, Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive doublewords in memory which make up each structure. Inactive structures are not written to memory.



ST3D { <Zt1>.D, <Zt2>.D, <Zt3>.D }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer offset = SInt(imm4);
integer nreg = 3;
```

Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 3 in the range -24 to 21, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = (offset * elements * nreg) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

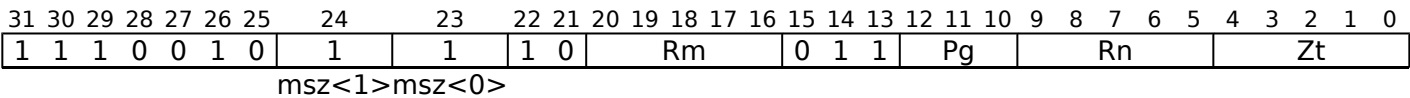
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# ST3D (scalar plus scalar)

Contiguous store three-doubleword structures from three vectors (scalar index)

Contiguous store three-doubleword structures, each from the same element number in three vector registers to the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by three. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive doublewords in memory which make up each structure. Inactive structures are not written to memory.



ST3D { <Zt1>.D, <Zt2>.D, <Zt3>.D }, <Pg>, [<Xn|SP>, <Xm>, LSL #3]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer nreg = 3;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(64) offset;
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = UInt(offset) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
```

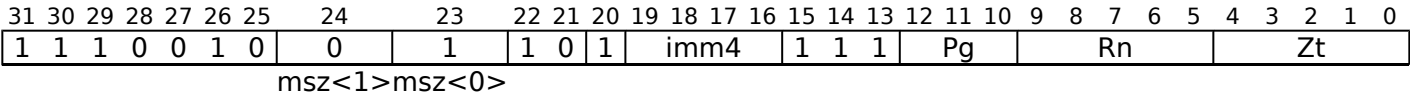
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# ST3H (scalar plus immediate)

Contiguous store three-halfword structures from three vectors (immediate index)

Contiguous store three-halfword structures, each from the same element number in three vector registers to the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 3 in the range -24 to 21 that is multiplied by the vector's in-memory size, irrespective of predication, Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive halfwords in memory which make up each structure. Inactive structures are not written to memory.



ST3H { <Zt1>.H, <Zt2>.H, <Zt3>.H }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer offset = SInt(imm4);
integer nreg = 3;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 3 in the range -24 to 21, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = (offset * elements * nreg) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

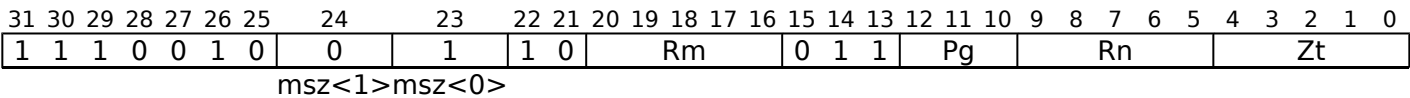
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# ST3H (scalar plus scalar)

Contiguous store three-halfword structures from three vectors (scalar index)

Contiguous store three-halfword structures, each from the same element number in three vector registers to the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by three. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive halfwords in memory which make up each structure. Inactive structures are not written to memory.



ST3H { <Zt1>.H, <Zt2>.H, <Zt3>.H }, <Pg>, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
integer nreg = 3;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(64) offset;
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = UInt(offset) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## ST3W (scalar plus immediate)

Contiguous store three-word structures from three vectors (immediate index)

Contiguous store three-word structures, each from the same element number in three vector registers to the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 3 in the range -24 to 21 that is multiplied by the vector's in-memory size, irrespective of predication,

Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive words in memory which make up each structure. Inactive structures are not written to memory.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	1	0	1	0	1	imm4			1	1	1	Pg						Rn			Zt				
msz<1>msz<0>																															

ST3W { <Zt1>.S, <Zt2>.S, <Zt3>.S }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```

if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer offset = SInt(imm4);
integer nreg = 3;

```

### Assembler Symbols

<Zt1>	Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
<Zt2>	Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
<Zt3>	Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<imm>	Is the optional signed immediate vector offset, a multiple of 3 in the range -24 to 21, defaulting to 0, encoded in the "imm4" field.

### Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = (offset * elements * nreg) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];

```

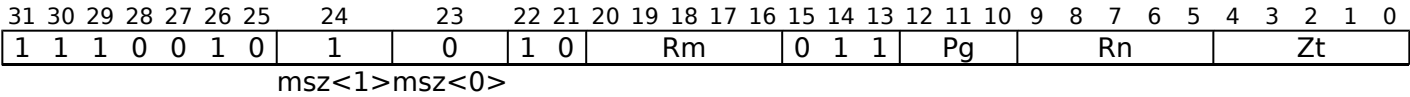


# ST3W (scalar plus scalar)

Contiguous store three-word structures from three vectors (scalar index)

Contiguous store three-word structures, each from the same element number in three vector registers to the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by three. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive words in memory which make up each structure. Inactive structures are not written to memory.



ST3W { <Zt1>.S, <Zt2>.S, <Zt3>.S }, <Pg>, [<Xn|SP>, <Xm>, LSL #2]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer nreg = 3;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(64) offset;
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = UInt(offset) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

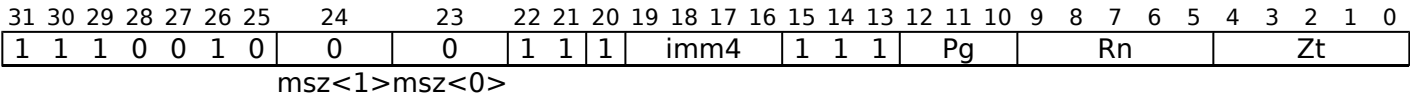
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# ST4B (scalar plus immediate)

Contiguous store four-byte structures from four vectors (immediate index)

Contiguous store four-byte structures, each from the same element number in four vector registers to the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 4 in the range -32 to 28 that is multiplied by the vector's in-memory size, irrespective of predication,

Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive bytes in memory which make up each structure. Inactive structures are not written to memory.



ST4B { <Zt1>.B, <Zt2>.B, <Zt3>.B, <Zt4>.B }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8;
integer offset = SInt(imm4);
integer nreg = 4;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 4 in the range -32 to 28, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = (offset * elements * nreg) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
```

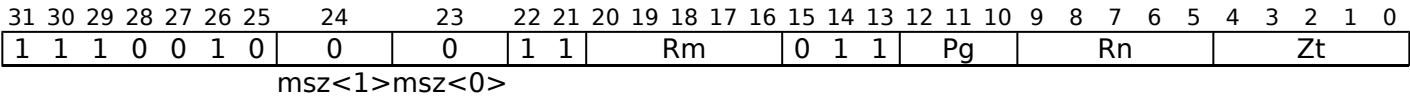
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# ST4B (scalar plus scalar)

Contiguous store four-byte structures from four vectors (scalar index)

Contiguous store four-byte structures, each from the same element number in four vector registers to the memory address generated by a 64-bit scalar base and a 64-bit scalar index register and added to the base address. After each structure access the index value is incremented by four. The index register is not updated by the instruction. Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive bytes in memory which make up each structure. Inactive structures are not written to memory.



ST4B { <Zt1>.B, <Zt2>.B, <Zt3>.B, <Zt4>.B }, <Pg>, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 8;
integer nreg = 4;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(64) offset;
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = UInt(offset) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
```

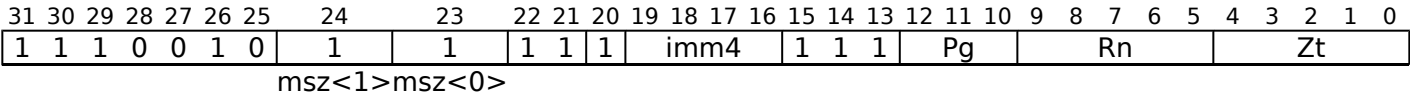
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# ST4D (scalar plus immediate)

Contiguous store four-doubleword structures from four vectors (immediate index)

Contiguous store four-doubleword structures, each from the same element number in four vector registers to the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 4 in the range -32 to 28 that is multiplied by the vector's in-memory size, irrespective of predication, Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive doublewords in memory which make up each structure. Inactive structures are not written to memory.



ST4D { <Zt1>.D, <Zt2>.D, <Zt3>.D, <Zt4>.D }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer offset = SInt(imm4);
integer nreg = 4;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 4 in the range -32 to 28, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = (offset * elements * nreg) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

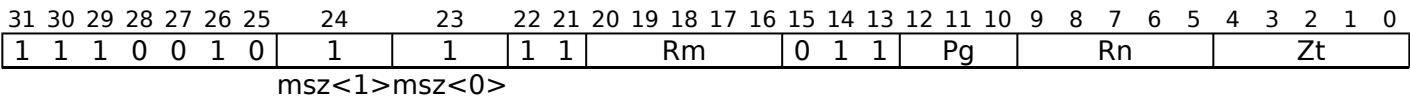
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## ST4D (scalar plus scalar)

Contiguous store four-doubleword structures from four vectors (scalar index)

Contiguous store four-doubleword structures, each from the same element number in four vector registers to the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by four. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive doublewords in memory which make up each structure. Inactive structures are not written to memory.



ST4D { <Zt1>.D, <Zt2>.D, <Zt3>.D, <Zt4>.D }, <Pg>, [<Xn|SP>, <Xm>, LSL #3]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer nreg = 4;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(64) offset;
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = UInt(offset) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
```

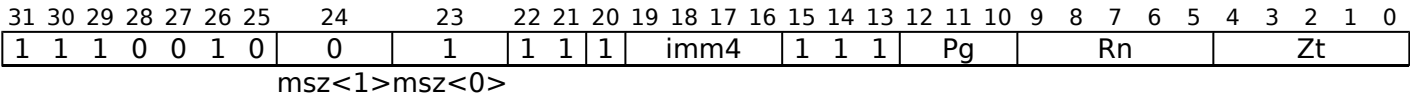
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# ST4H (scalar plus immediate)

Contiguous store four-halfword structures from four vectors (immediate index)

Contiguous store four-halfword structures, each from the same element number in four vector registers to the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 4 in the range -32 to 28 that is multiplied by the vector's in-memory size, irrespective of predication,  
Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive halfwords in memory which make up each structure. Inactive structures are not written to memory.



ST4H { <Zt1>.H, <Zt2>.H, <Zt3>.H, <Zt4>.H }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer offset = SInt(imm4);
integer nreg = 4;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 4 in the range -32 to 28, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = (offset * elements * nreg) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

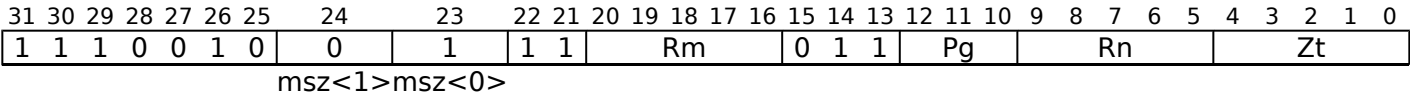
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# ST4H (scalar plus scalar)

Contiguous store four-halfword structures from four vectors (scalar index)

Contiguous store four-halfword structures, each from the same element number in four vector registers to the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by four. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive halfwords in memory which make up each structure. Inactive structures are not written to memory.



ST4H { <Zt1>.H, <Zt2>.H, <Zt3>.H, <Zt4>.H }, <Pg>, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
integer nreg = 4;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(64) offset;
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = UInt(offset) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
```

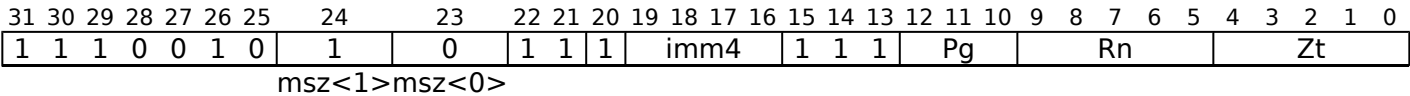
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# ST4W (scalar plus immediate)

Contiguous store four-word structures from four vectors (immediate index)

Contiguous store four-word structures, each from the same element number in four vector registers to the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 4 in the range -32 to 28 that is multiplied by the vector's in-memory size, irrespective of predication,  
Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive words in memory which make up each structure. Inactive structures are not written to memory.



ST4W { <Zt1>.S, <Zt2>.S, <Zt3>.S, <Zt4>.S }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer offset = SInt(imm4);
integer nreg = 4;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 4 in the range -32 to 28, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = (offset * elements * nreg) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

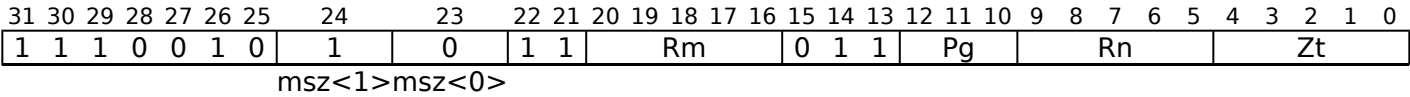
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# ST4W (scalar plus scalar)

Contiguous store four-word structures from four vectors (scalar index)

Contiguous store four-word structures, each from the same element number in four vector registers to the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by four. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive words in memory which make up each structure. Inactive structures are not written to memory.



ST4W { <Zt1>.S, <Zt2>.S, <Zt3>.S, <Zt4>.S }, <Pg>, [<Xn|SP>, <Xm>, LSL #2]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer nreg = 4;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(PL) mask = P[g];
bits(64) offset;
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            integer eoff = UInt(offset) + (e * nreg) + r;
            bits(64) addr = base + eoff * mbytes;
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

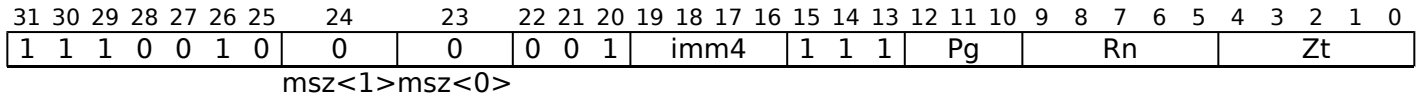
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## STNT1B (scalar plus immediate)

Contiguous store non-temporal bytes from vector (immediate index)

Contiguous store non-temporal of bytes from elements of a vector register to the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements are not written to memory.

A non-temporal store is a hint to the system that this data is unlikely to be referenced again soon.



STNT1B { <Zt>.B }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8;
integer offset = SInt(imm4);
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
constant integer mbytes = esize DIV 8;
bits(VL) src;
bits(PL) mask = P[g];

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    src = Z[t];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + eoff * mbytes;
        Mem[addr, mbytes, AccType_STREAM] = Elem[src, e, esize];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

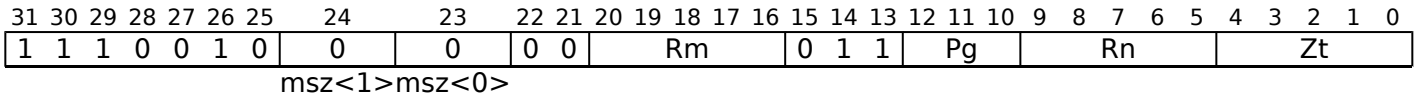
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## STNT1B (scalar plus scalar)

Contiguous store non-temporal bytes from vector (scalar index)

Contiguous store non-temporal of bytes from elements of a vector register to the memory address generated by a 64-bit scalar base and scalar index which is added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements are not written to memory.

A non-temporal store is a hint to the system that this data is unlikely to be referenced again soon.



STNT1B { <Zt>.B }, <Pg>, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 8;
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) offset;
bits(VL) src;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];
    src = Z[t];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = base + (UInt(offset) + e) * mbytes;
        Mem[addr, mbytes, AccType_STREAM] = Elem[src, e, esize];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

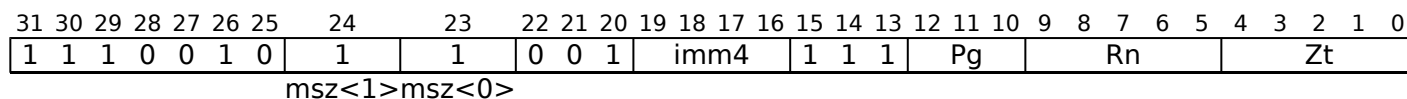
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## STNT1D (scalar plus immediate)

Contiguous store non-temporal doublewords from vector (immediate index)

Contiguous store non-temporal of doublewords from elements of a vector register to the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements are not written to memory.

A non-temporal store is a hint to the system that this data is unlikely to be referenced again soon.



STNT1D { <Zt>.D }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer offset = SInt(imm4);
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
constant integer mbytes = esize DIV 8;
bits(VL) src;
bits(PL) mask = P[g];

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    src = Z[t];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + eoff * mbytes;
        Mem[addr, mbytes, AccType_STREAM] = Elem[src, e, esize];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

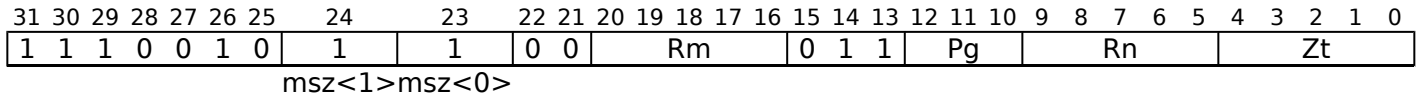


## STNT1D (scalar plus scalar)

Contiguous store non-temporal doublewords from vector (scalar index)

Contiguous store non-temporal of doublewords from elements of a vector register to the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 8 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements are not written to memory.

A non-temporal store is a hint to the system that this data is unlikely to be referenced again soon.



STNT1D { <Zt>.D }, <Pg>, [<Xn|SP>, <Xm>, LSL #3]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) offset;
bits(VL) src;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    else
        if n == 31 then CheckSPAlignment();
        base = if n == 31 then SP[] else X[n];
        offset = X[m];
        src = Z[t];

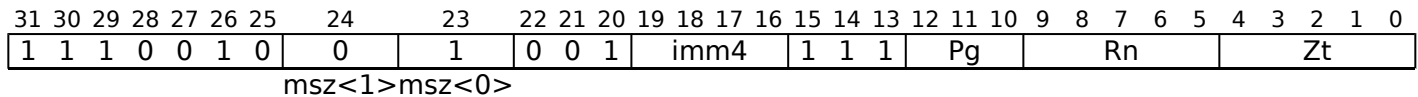
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = base + (UInt(offset) + e) * mbytes;
        Mem[addr, mbytes, AccType_STREAM] = Elem[src, e, esize];
```

## STNT1H (scalar plus immediate)

Contiguous store non-temporal halfwords from vector (immediate index)

Contiguous store non-temporal of halfwords from elements of a vector register to the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements are not written to memory.

A non-temporal store is a hint to the system that this data is unlikely to be referenced again soon.



STNT1H { <Zt>.H }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer offset = Int(imm4);
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
constant integer mbytes = esize DIV 8;
bits(VL) src;
bits(PL) mask = P[g];

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    src = Z[t];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + eoff * mbytes;
        Mem[addr, mbytes, AccType_STREAM] = Elem[src, e, esize];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

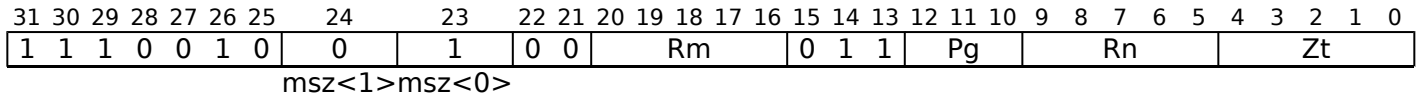
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## STNT1H (scalar plus scalar)

Contiguous store non-temporal halfwords from vector (scalar index)

Contiguous store non-temporal of halfwords from elements of a vector register to the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 2 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements are not written to memory.

A non-temporal store is a hint to the system that this data is unlikely to be referenced again soon.



STNT1H { <Zt>.H }, <Pg>, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) offset;
bits(VL) src;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];
    src = Z[t];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = base + (UInt(offset) + e) * mbytes;
        Mem[addr, mbytes, AccType_STREAM] = Elem[src, e, esize];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

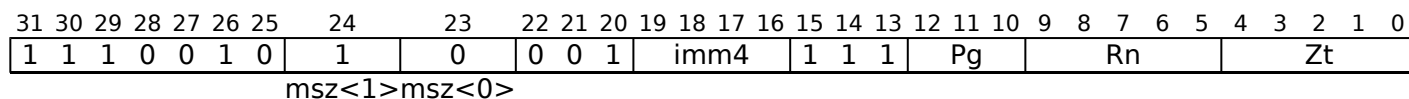
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## STNT1W (scalar plus immediate)

Contiguous store non-temporal words from vector (immediate index)

Contiguous store non-temporal of words from elements of a vector register to the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements are not written to memory.

A non-temporal store is a hint to the system that this data is unlikely to be referenced again soon.



STNT1W { <Zt>.S }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer offset = SInt(imm4);
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
constant integer mbytes = esize DIV 8;
bits(VL) src;
bits(PL) mask = P[g];

if HaveMTEExt() then SetTagCheckedInstruction(n != 31);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    src = Z[t];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer eoff = (offset * elements) + e;
        bits(64) addr = base + eoff * mbytes;
        Mem[addr, mbytes, AccType_STREAM] = Elem[src, e, esize];
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

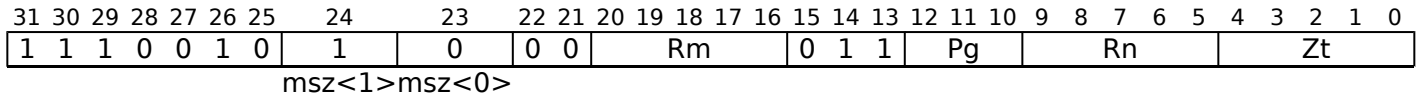
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## STNT1W (scalar plus scalar)

Contiguous store non-temporal words from vector (scalar index)

Contiguous store non-temporal of words from elements of a vector register to the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 4 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements are not written to memory.

A non-temporal store is a hint to the system that this data is unlikely to be referenced again soon.



STNT1W { <Zt>.S }, <Pg>, [<Xn|SP>, <Xm>, LSL #2]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) offset;
bits(VL) src;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if !AnyActiveElement(mask, esize) then
    if n == 31 && ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
else
    if n == 31 then CheckSPAlignment();
    base = if n == 31 then SP[] else X[n];
    offset = X[m];
    src = Z[t];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(64) addr = base + (UInt(offset) + e) * mbytes;
        Mem[addr, mbytes, AccType_STREAM] = Elem[src, e, esize];
```

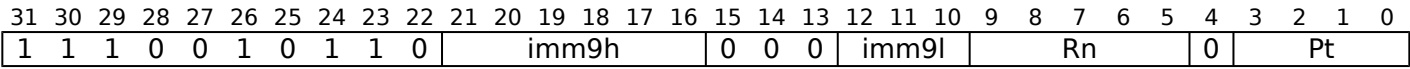
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# STR (predicate)

Store predicate register

Store a predicate register to a memory address generated by a 64-bit scalar base, plus an immediate offset in the range -256 to 255 which is multiplied by the current predicate register size in bytes. This instruction is unpredicated. The store is performed as a stream of bytes containing 8 consecutive predicate bits in ascending element order, without any endian conversion.



STR <Pt>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Pt);
integer n = UInt(Rn);
integer imm = SInt(imm9h:imm9l);
```

## Assembler Symbols

- <Pt> Is the name of the scalable predicate transfer register, encoded in the "Pt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -256 to 255, defaulting to 0, encoded in the "imm9h:imm9l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = PL DIV 8;
bits(PL) src;
bits(64) base;
integer offset = imm * elements;

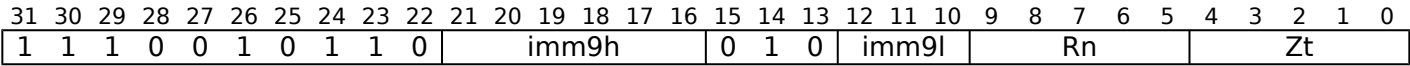
if n == 31 then
    CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

src = P[t];
boolean aligned = AArch64.CheckAlignment(base + offset, 2, AccType_NORMAL, TRUE);
for e = 0 to elements-1
    AArch64.MemSingle[base + offset, 1, AccType_NORMAL, aligned] = Elem[src, e, 8];
    offset = offset + 1;
```

# STR (vector)

Store vector register

Store a vector register to a memory address generated by a 64-bit scalar base, plus an immediate offset in the range -256 to 255 which is multiplied by the current vector register size in bytes. This instruction is unpredicated. The store is performed as a stream of byte elements in ascending element order, without any endian conversion.



STR <Zt>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer imm = SInt(imm9h:imm9l);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -256 to 255, defaulting to 0, encoded in the "imm9h:imm9l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV 8;
bits(VL) src;
bits(64) base;
integer offset = imm * elements;

if n == 31 then
    CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

src = Z[t];
boolean aligned = AArch64.CheckAlignment(base + offset, 16, AccType_NORMAL, TRUE);
for e = 0 to elements-1
    AArch64.MemSingle[base + offset, 1, AccType_NORMAL, aligned] = Elem[src, e, 8];
    offset = offset + 1;
```

# SUB (vectors, predicated)

Subtract vectors (predicated)

Subtract active elements of the second source vector from corresponding elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	0	0	0	0	1	0	0	0	Pg	Zm				Zdn								

SUB <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = element1 - element2;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];
Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.





# SUB (immediate)

Subtract immediate (unpredicated)

Subtract an unsigned immediate from each element of the source vector, and destructively place the results in the corresponding elements of the source vector. This instruction is unpredicated.

The immediate is an unsigned value in the range 0 to 255, and for element widths of 16 bits or higher it may also be a positive multiple of 256 in the range 256 to 65280.

The immediate is encoded in 8 bits with an optional left shift by 8. The preferred disassembly when the shift option is specified is "#<uimm8>, LSL #8". However an assembler and disassembler may also allow use of the shifted 16-bit value unless the immediate is 0 and the shift amount is 8, which must be unambiguously described as "#0, LSL #8".

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	0	0	0	0	1	1	1	sh	imm8								Zdn					

SUB <Zdn>.<T>, <Zdn>.<T>, #<imm>{, <shift>}

```
if !HaveSVE() then UNDEFINED;
if size:sh == '001' then UNDEFINED;
integer esize = 8 << UInt(size);
integer dn = UInt(Zdn);
integer imm = UInt(imm8);
if sh == '1' then imm = imm << 8;
```

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<imm> Is an unsigned immediate in the range 0 to 255, encoded in the "imm8" field.

<shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #8

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    Elem[result, e, esize] = element1 - imm;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SUB (vectors, unpredicated)

Subtract vectors (unpredicated)

Subtract all elements of the second source vector from corresponding elements of the first source vector and place the results in the corresponding elements of the destination vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1	Zm			0	0	0	0	0	1	Zn			Zd									

SUB <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = element1 - element2;

Z[d] = result;
```

# SUBR (vectors)

Reversed subtract vectors (predicated)

Reversed subtract active elements of the first source vector from corresponding elements of the second source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	0	0	0	1	1	0	0	0		Pg					Zm					Zdn		

SUBR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = element2 - element1;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];
Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



# SUBR (immediate)

Reversed subtract from immediate (unpredicated)

Reversed subtract from an unsigned immediate each element of the source vector, and destructively place the results in the corresponding elements of the source vector. This instruction is unpredicated.

The immediate is an unsigned value in the range 0 to 255, and for element widths of 16 bits or higher it may also be a positive multiple of 256 in the range 256 to 65280.

The immediate is encoded in 8 bits with an optional left shift by 8. The preferred disassembly when the shift option is specified is "#<uimm8>, LSL #8". However an assembler and disassembler may also allow use of the shifted 16-bit value unless the immediate is 0 and the shift amount is 8, which must be unambiguously described as "#0, LSL #8".

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	0	0	0	1	1	1	1	1	sh	imm8								Zdn				

SUBR <Zdn>.<T>, <Zdn>.<T>, #<imm>{, <shift>}

```
if !HaveSVE() then UNDEFINED;
if size:sh == '001' then UNDEFINED;
integer esize = 8 << UInt(size);
integer dn = UInt(Zdn);
integer imm = UInt(imm8);
if sh == '1' then imm = imm << 8;
```

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<imm> Is an unsigned immediate in the range 0 to 255, encoded in the "imm8" field.

<shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #8

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    Elem[result, e, esize] = (imm - element1)<esize-1:0>;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

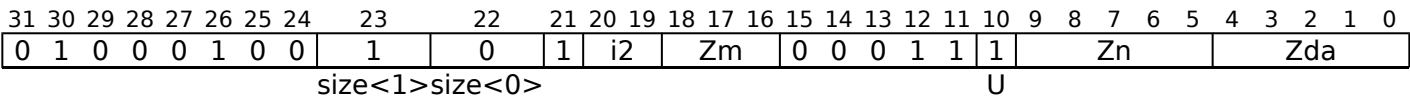


# SUDOT

Signed by unsigned integer indexed dot product

The signed by unsigned integer indexed dot product instruction computes the dot product of a group of four signed 8-bit integer values held in each 32-bit element of the first source vector multiplied by a group of four unsigned 8-bit integer values in an indexed 32-bit element of the second source vector, and then destructively adds the widened dot product to the corresponding 32-bit element of the destination vector.

The groups within the second source vector are specified using an immediate index which selects the same group position within each 128-bit vector segment. The index range is from 0 to 3. This instruction is unpredicated. ID\_AA64ZFR0\_EL1.I8MM indicates whether this instruction is implemented.



SUDOT <Zda>.S, <Zn>.B, <Zm>.B[<imm>]

```
if !HaveSVE() || !HaveInt8MatMulExt() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.
- <imm> Is the immediate index of a quadruplet of four 8-bit elements within each 128-bit vector segment, in the range 0 to 3, encoded in the "i2" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer eltsperssegment = 128 DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltsperssegment);
    integer s = segmentbase + index;
    bits(esize) res = Elem[operand3, e, esize];
    for i = 0 to 3
        integer element1 = SInt(Elem[operand1, 4 * e + i, esize DIV 4]);
        integer element2 = UInt(Elem[operand2, 4 * s + i, esize DIV 4]);
        res = res + element1 * element2;
    Elem[result, e, esize] = res;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.

- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SUNPKHI, SUNPKLO

Signed unpack and extend half of vector

Unpack elements from the lowest or highest half of the source vector and then sign-extend them to place in elements of twice their size within the destination vector. This instruction is unpredicated.

It has encodings from 2 classes: [High half](#) and [Low half](#)

## High half

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	1	0	0	0	1	0	0	1	1	1	0	Zn				Zd						
														U	H																

SUNPKHI <Zd>.<T>, <Zn>.<Tb>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean unsigned = FALSE;
boolean hi = TRUE;
```

## Low half

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	1	0	0	0	0	0	0	1	1	1	0	Zn				Zd						
														U	H																

SUNPKLO <Zd>.<T>, <Zn>.<Tb>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean unsigned = FALSE;
boolean hi = FALSE;
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
integer hsize = esize DIV 2;
bits(VL) operand = Z[n];
bits(VL) result;

for e = 0 to elements-1
    bits(hsize) element = if hi then Elem[operand, e + elements, hsize] else Elem[operand, e, hsize];
    Elem[result, e, esize] = Extend(element, esize, unsigned);

Z[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# SXTB, SXTH, SXTW

Signed byte / halfword / word extend (predicated)

Sign-extend the least-significant sub-element of each active element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

It has encodings from 3 classes: [Byte](#) , [Halfword](#) and [Word](#)

## Byte

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	0	0	0	0	1	0	1	Pg			Zn				Zd						
																U															

SXTB <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer s_esize = 8;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean unsigned = FALSE;
```

## Halfword

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	0	0	1	0	0	1	0	1	Pg			Zn					Zd				
U																															

SXTH <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size != '1x' then UNDEFINED;
integer esize = 8 << UInt(size);
integer s_esize = 16;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean unsigned = FALSE;
```

## Word

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	0	1	0	0	1	0	1	Pg			Zn			Zd							
U																															

SXTW <Zd>.D, <Pg>/M, <Zn>.D

```
if !HaveSVE() then UNDEFINED;
if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer s_esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean unsigned = FALSE;
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> For the byte variant: is the size specifier, encoded in “size”:

size	<T>
00	RESERVED
01	H
10	S
11	D

For the halfword variant: is the size specifier, encoded in “size<0>”:

size<0>	<T>
0	S
1	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) result = Z[d];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element = Elem[operand, e, esize];
        Elem[result, e, esize] = Extend(element<s_ensure-1:0>, esize, unsigned);

Z[d] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

TBL

Programmable table lookup in single vector table

Reads each element of the second source (index) vector and uses its value to select an indexed element from the first source (table) vector, and places the indexed table element in the destination vector element corresponding to the index vector element. If an index value is greater than or equal to the number of vector elements then it places zero in the corresponding destination vector element.

Since the index values can select any element in a vector this operation is not naturally vector length agnostic.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	Zm						0	0	1	1	0	0	Zn						Zd			

TBL <Zd>.<T>, { <Zn>.<T> }, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer idx = UInt(Elem[operand2, e, esize]);
    Elem[result, e, esize] = if idx < elements then Elem[operand1, idx, esize] else Zeros();
Z[d] = result;
```

# TRN1, TRN2 (predicates)

Interleave even or odd elements from two predicates

Interleave alternating even or odd-numbered elements from the first and second source predicates and place in elements of the destination predicate. This instruction is unpredicated.

It has encodings from 2 classes: [Even](#) and [Odd](#)

## Even

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	Pm				0	1	0	1	0	0	0	Pn				0	Pd				
H																															

TRN1 [<Pd>.<T>](#), [<Pn>.<T>](#), [<Pm>.<T>](#)

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
integer part = 0;
```

## Odd

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	Pm				0	1	0	1	0	1	0	Pn				0	Pd				
H																															

TRN2 [<Pd>.<T>](#), [<Pn>.<T>](#), [<Pm>.<T>](#)

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
integer part = 1;
```

## Assembler Symbols

- <Pd>

Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <Pn>

Is the name of the first source scalable predicate register, encoded in the "Pn" field.
- <Pm>

Is the name of the second source scalable predicate register, encoded in the "Pm" field.



## Operation

```
CheckSVEEnabled();
integer pairs = VL DIV (esize * 2);
bits(PL) operand1 = P[n];
bits(PL) operand2 = P[m];
bits(PL) result;

for p = 0 to pairs-1
    Elem[result, 2*p+0, esize DIV 8] = Elem[operand1, 2*p+part, esize DIV 8];
    Elem[result, 2*p+1, esize DIV 8] = Elem[operand2, 2*p+part, esize DIV 8];

P[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## TRN1, TRN2 (vectors)

Interleave even or odd elements from two vectors

Interleave alternating even or odd-numbered elements from the first and second source vectors and place in elements of the destination vector. This instruction is unpredicated. The 128-bit element variant of this instruction requires that the current vector length is at least 256 bits, and if the current vector length is not an integer multiple of 256 bits then the trailing bits are set to zero.

ID\_AA64ZFR0\_EL1.F64MM indicates whether the 128-bit element variant of the instruction is implemented.

It has encodings from 4 classes: [Even](#) , [Even \(quadwords\)](#) , [Odd](#) and [Odd \(quadwords\)](#)

### Even

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	Zm				0	1	1	1	0	0	Zn				Zd							
																										H					

TRN1 [<Zd>.<T>](#), [<Zn>.<T>](#), [<Zm>.<T>](#)

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer part = 0;
```

### Even (quadwords)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	1	0	1	Zm					0	0	0	1	1	0	Zn					Zd				
																										H					

TRN1 [<Zd>.Q](#), [<Zn>.Q](#), [<Zm>.Q](#)

```
if !HaveSVEFP64MatMulExt() then UNDEFINED;
integer esize = 128;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer part = 0;
```

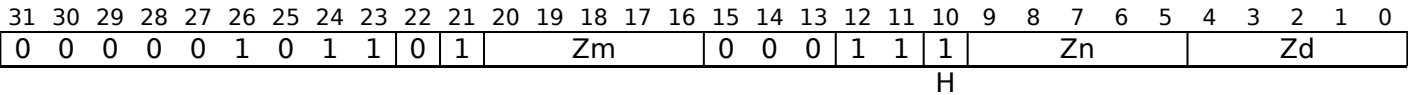
### Odd

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	Zm						0	1	1	1	0	1	Zn						Zd			
																										H					

TRN2 [<Zd>.<T>](#), [<Zn>.<T>](#), [<Zm>.<T>](#)

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer part = 1;
```

Odd (quadwords)



TRN2 <Zd>.Q, <Zn>.Q, <Zm>.Q

```
if !HaveSVEFP64MatMulExt() then UNDEFINED;
integer esize = 128;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer part = 1;
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
if VL < esize * 2 then UNDEFINED;
integer pairs = VL DIV (esize * 2);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Zeros();

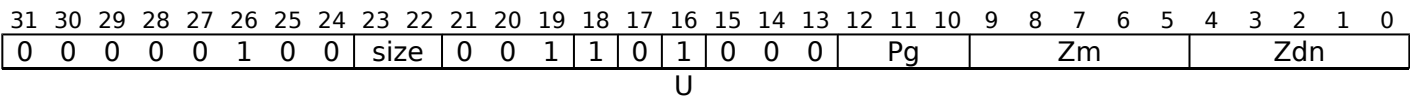
for p = 0 to pairs-1
    Elem[result, 2*p+0, esize] = Elem[operand1, 2*p+part, esize];
    Elem[result, 2*p+1, esize] = Elem[operand2, 2*p+part, esize];

Z[d] = result;
```

# UABD

Unsigned absolute difference (predicated)

Compute the absolute difference between unsigned integer values in active elements of the second source vector and corresponding elements of the first source vector and destructively place the difference in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



UABD <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean unsigned = TRUE;
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    if ElemP[mask, e, esize] == '1' then
        integer absdiff = Abs(element1 - element2);
        Elem[result, e, esize] = absdiff<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

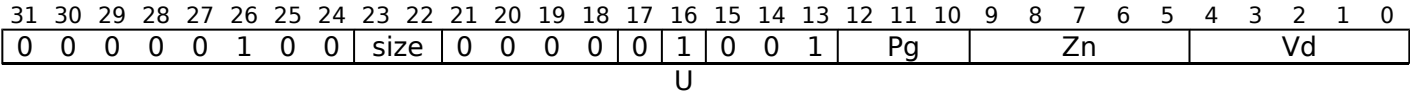
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UADDV

Unsigned add reduction to scalar

Unsigned add horizontally across all lanes of a vector, and place the result in the SIMD&FP scalar destination register. Narrow elements are first zero-extended to 64 bits. Inactive elements in the source vector are treated as zero.



UADDV <Dd>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
```

Assembler Symbols

- <Dd>

Is the 64-bit name of the destination SIMD&FP register, encoded in the "Vd" field.
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn>

Is the name of the source scalable vector register, encoded in the "Zn" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
integer sum = 0;

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer element = UInt(Elem[operand, e, esize]);
        sum = sum + element;

V[d] = sum<63:0>;
```

# UCVTF

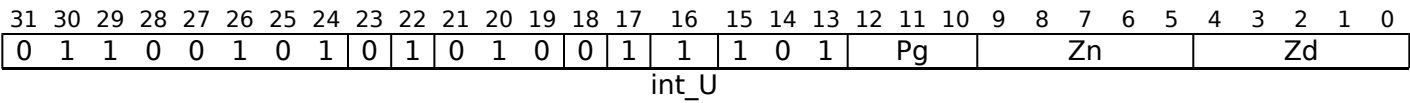
Unsigned integer convert to floating-point (predicated)

Convert to floating-point from the unsigned integer in each active element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

If the input and result types have a different size the smaller type is held unpacked in the least significant bits of elements of the larger size. When the input is the smaller type the upper bits of each source element are ignored. When the result is the smaller type the results are zero-extended to fill each destination element.

It has encodings from 7 classes: [16-bit to half-precision](#) , [32-bit to half-precision](#) , [32-bit to single-precision](#) , [32-bit to double-precision](#) , [64-bit to half-precision](#) , [64-bit to single-precision](#) and [64-bit to double-precision](#)

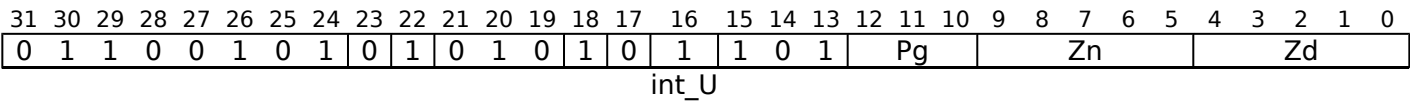
## 16-bit to half-precision



UCVTF <Zd>.H, <Pg>/M, <Zn>.H

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 16;
integer d_esize = 16;
boolean unsigned = TRUE;
FPRounding rounding = FPRoundingMode(FPCR[]);
```

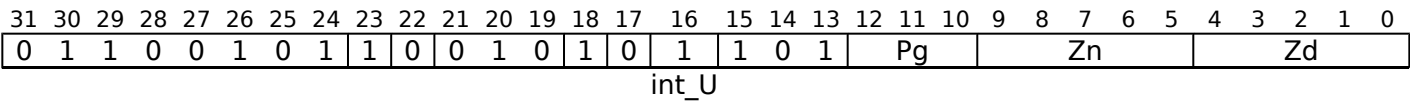
## 32-bit to half-precision



UCVTF <Zd>.H, <Pg>/M, <Zn>.S

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 32;
integer d_esize = 16;
boolean unsigned = TRUE;
FPRounding rounding = FPRoundingMode(FPCR[]);
```

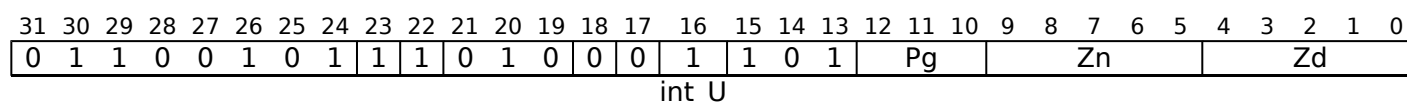
## 32-bit to single-precision



UCVTF <Zd>.S, <Pg>/M, <Zn>.S

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 32;
integer d_esize = 32;
boolean unsigned = TRUE;
FPRounding rounding = FPRoundingMode(FPCR[]);
```

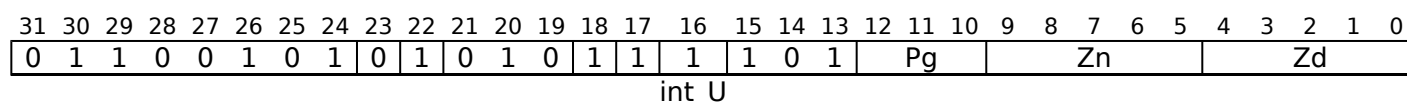
### 32-bit to double-precision



UCVTF <Zd>.D, <Pg>/M, <Zn>.S

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 32;
integer d_esize = 64;
boolean unsigned = TRUE;
FPRounding rounding = FPRoundingMode(FPCR[]);
```

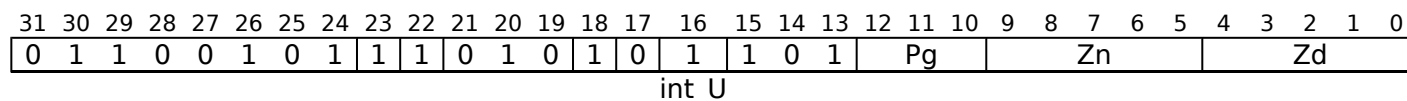
### 64-bit to half-precision



UCVTF <Zd>.H, <Pg>/M, <Zn>.D

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 64;
integer d_esize = 16;
boolean unsigned = TRUE;
FPRounding rounding = FPRoundingMode(FPCR[]);
```

### 64-bit to single-precision

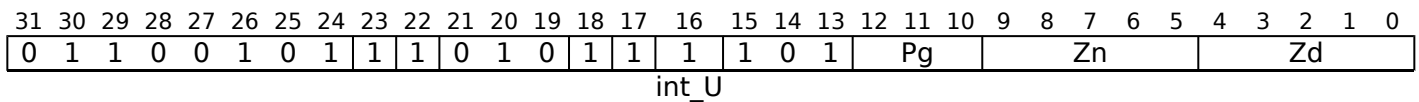




UCVTF <Zd>.S, <Pg>/M, <Zn>.D

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_ensure = 64;
integer d_ensure = 32;
boolean unsigned = TRUE;
FPRounding rounding = FPRoundingMode(FPCR[]);
```

## 64-bit to double-precision



UCVTF <Zd>.D, <Pg>/M, <Zn>.D

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_ensure = 64;
integer d_ensure = 64;
boolean unsigned = TRUE;
FPRounding rounding = FPRoundingMode(FPCR[]);
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) result = Z[d];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element = Elem[operand, e, esize];
        bits(d_ensure) fpval = FixedToFP(element<s_ensure-1:0>, 0, unsigned, FPCR[], rounding);
        Elem[result, e, esize] = ZeroExtend(fpval);

Z[d] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

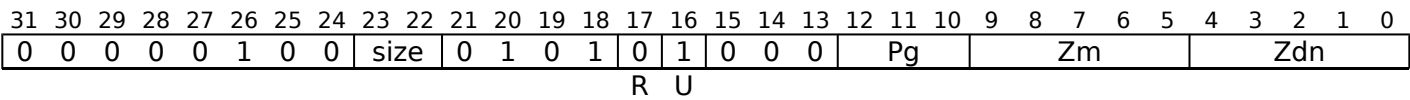
- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



# UDIV

Unsigned divide (predicated)

Unsigned divide active elements of the first source vector by corresponding elements of the second source vector and destructively place the quotient in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



UDIV <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '0x' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean unsigned = TRUE;
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size<0>":

size<0>	<T>
0	S
1	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    if ElemP[mask, e, esize] == '1' then
        integer element2 = Int(Elem[operand2, e, esize], unsigned);
        integer quotient;
        if element2 == 0 then
            quotient = 0;
        else
            quotient = RoundTowardsZero(Real(element1) / Real(element2));
        Elem[result, e, esize] = quotient<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

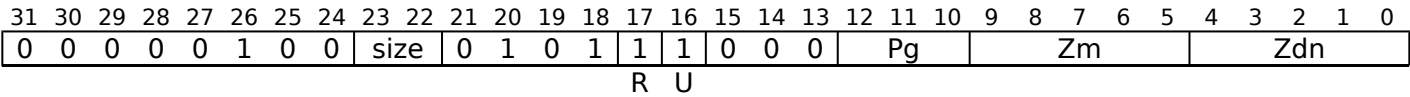
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UDIVR

Unsigned reversed divide (predicated)

Unsigned reversed divide active elements of the second source vector by corresponding elements of the first source vector and destructively place the quotient in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



```
UDIVR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>
```

```
if !HaveSVE() then UNDEFINED;
if size == '0x' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean unsigned = TRUE;
```

Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size<0>":

size<0>	<T>
0	S
1	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    if ElemP[mask, e, esize] == '1' then
        integer element2 = Int(Elem[operand2, e, esize], unsigned);
        integer quotient;
        if element1 == 0 then
            quotient = 0;
        else
            quotient = RoundTowardsZero(Real(element2) / Real(element1));
        Elem[result, e, esize] = quotient<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

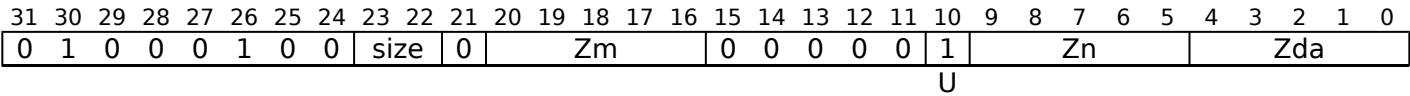
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# UDOT (vectors)

Unsigned integer dot product

The unsigned integer dot product instruction computes the dot product of a group of four unsigned 8-bit or 16-bit integer values held in each 32-bit or 64-bit element of the first source vector multiplied by a group of four unsigned 8-bit or 16-bit integer values in the corresponding 32-bit or 64-bit element of the second source vector, and then destructively adds the widened dot product to the corresponding 32-bit or 64-bit element of the destination vector. This instruction is unpredicated.



UDOT <Zda>.<T>, <Zn>.<Tb>, <Zm>.<Tb>

```
if !HaveSVE() then UNDEFINED;
if size == '0x' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

<Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.

<T> Is the size specifier, encoded in "size<0>":

size<0>	<T>
0	S
1	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size<0>":

size<0>	<Tb>
0	B
1	H

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) res = Elem[operand3, e, esize];
    for i = 0 to 3
        integer element1 = UInt(Elem[operand1, 4 * e + i, esize DIV 4]);
        integer element2 = UInt(Elem[operand2, 4 * e + i, esize DIV 4]);
        res = res + element1 * element2;
    Elem[result, e, esize] = res;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



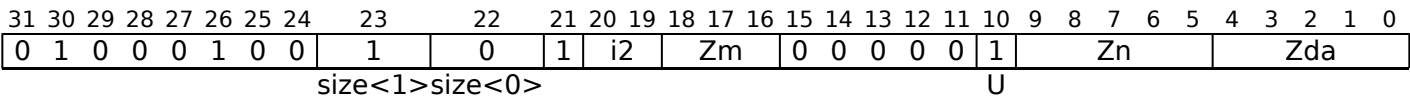
# UDOT (indexed)

Unsigned integer indexed dot product

The unsigned integer indexed dot product instruction computes the dot product of a group of four unsigned 8-bit or 16-bit integer values held in each 32-bit or 64-bit element of the first source vector multiplied by a group of four unsigned 8-bit or 16-bit integer values in an indexed 32-bit or 64-bit element of the second source vector, and then destructively adds the widened dot product to the corresponding 32-bit or 64-bit element of the destination vector. The groups within the second source vector are specified using an immediate index which selects the same group position within each 128-bit vector segment. The index range is from 0 to one less than the number of groups per 128-bit segment, encoded in 1 to 2 bits depending on the size of the group. This instruction is unpredicated.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

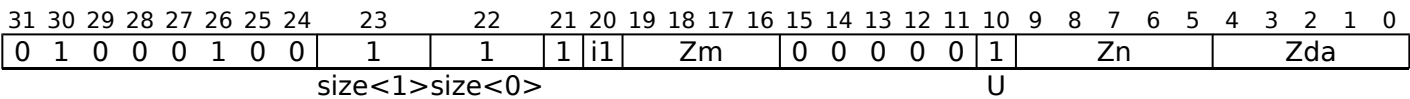
## 32-bit



UDOT <Zda>.S, <Zn>.B, <Zm>.B[<imm>]

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## 64-bit



UDOT <Zda>.D, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer index = UInt(i1);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> For the 32-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  
For the 64-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
- <imm> For the 32-bit variant: is the immediate index of a quadruplet of four 8-bit elements within each 128-bit vector segment, in the range 0 to 3, encoded in the "i2" field.  
For the 64-bit variant: is the immediate index of a quadruplet of four 16-bit elements within each 128-bit vector segment, in the range 0 to 1, encoded in the "i1" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer eltspersegment = 128 DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltspersegment);
    integer s = segmentbase + index;
    bits(esize) res = Elem[operand3, e, esize];
    for i = 0 to 3
        integer element1 = UInt(Elem[operand1, 4 * e + i, esize DIV 4]);
        integer element2 = UInt(Elem[operand2, 4 * s + i, esize DIV 4]);
        res = res + element1 * element2;
    Elem[result, e, esize] = res;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

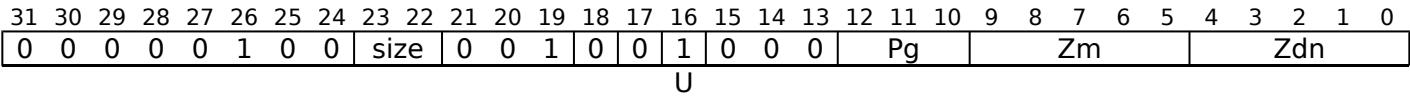
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# UMAX (vectors)

Unsigned maximum vectors (predicated)

Determine the unsigned maximum of active elements of the second source vector and corresponding elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



```
UMAX <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean unsigned = TRUE;
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    if ElemP[mask, e, esize] == '1' then
        integer maximum = Max(element1, element2);
        Elem[result, e, esize] = maximum<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];
Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

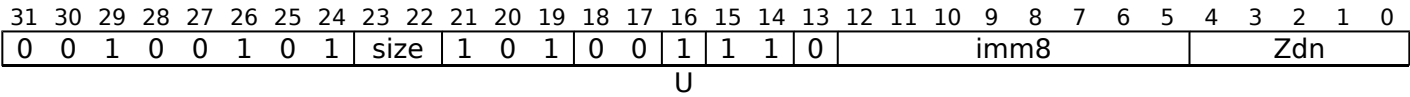
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# UMAX (immediate)

Unsigned maximum with immediate (unpredicated)

Determine the unsigned maximum of an immediate and each element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate is an unsigned 8-bit value in the range 0 to 255, inclusive. This instruction is unpredicated.



UMAX <Zdn>.<T>, <Zdn>.<T>, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer dn = UInt(Zdn);
boolean unsigned = TRUE;
integer imm = Int(imm8, unsigned);
```

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<imm> Is the unsigned immediate operand, in the range 0 to 255, encoded in the "imm8" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    Elem[result, e, esize] = Max(element1, imm)<esize-1:0>;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

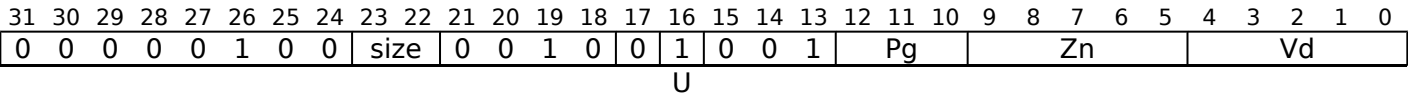
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UMAXV

Unsigned maximum reduction to scalar

Unsigned maximum horizontally across all lanes of a vector, and place the result in the SIMD&FP scalar destination register. Inactive elements in the source vector are treated as zero.



UMAXV <V><d>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
boolean unsigned = TRUE;
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D

<d> Is the number [0-31] of the destination SIMD&FP register, encoded in the "Vd" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<T> Is the size specifier, encoded in “size”:

size	<T>
00	B
01	H
10	S
11	D

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
integer maximum = if unsigned then 0 else -(2^(esize-1));

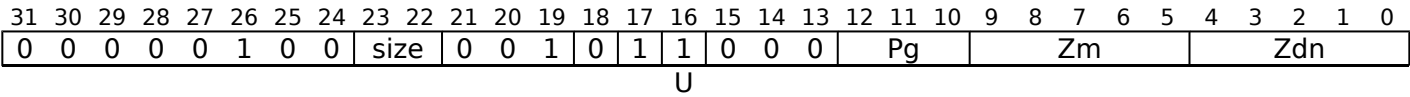
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer element = Int(Elem[operand, e, esize], unsigned);
        maximum = Max(maximum, element);

V[d] = maximum<esize-1:0>;
```

# UMIN (vectors)

Unsigned minimum vectors (predicated)

Determine the unsigned minimum of active elements of the second source vector and corresponding elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



```
UMIN <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean unsigned = TRUE;
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    if ElemP[mask, e, esize] == '1' then
        integer minimum = Min(element1, element2);
        Elem[result, e, esize] = minimum<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

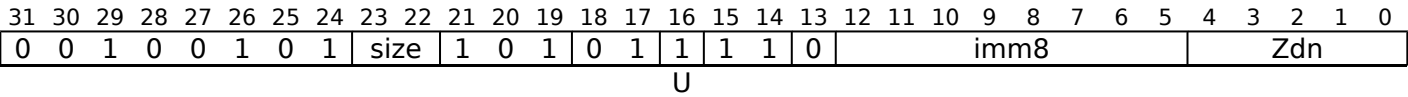
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



UMIN (immediate)

Unsigned minimum with immediate (unpredicated)

Determine the unsigned minimum of an immediate and each element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate is an unsigned 8-bit value in the range 0 to 255, inclusive. This instruction is unpredicated.



```
UMIN <Zdn>.<T>, <Zdn>.<T>, #<imm>
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer dn = UInt(Zdn);
boolean unsigned = TRUE;
integer imm = Int(imm8, unsigned);
```

Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<imm> Is the unsigned immediate operand, in the range 0 to 255, encoded in the "imm8" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    Elem[result, e, esize] = Min(element1, imm)<esize-1:0>;

Z[dn] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

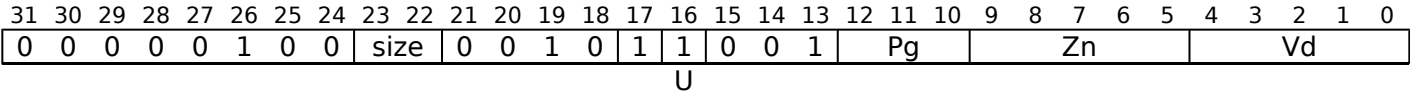
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UMINV

Unsigned minimum reduction to scalar

Unsigned minimum horizontally across all lanes of a vector, and place the result in the SIMD&FP scalar destination register. Inactive elements in the source vector are treated as the maximum unsigned integer for the element size.



UMINV <V><d>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
boolean unsigned = TRUE;
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D

<d> Is the number [0-31] of the destination SIMD&FP register, encoded in the "Vd" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<T> Is the size specifier, encoded in “size”:

size	<T>
00	B
01	H
10	S
11	D

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
integer minimum = if unsigned then (2^esize - 1) else (2^(esize-1) - 1);

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer element = Int(Elem[operand, e, esize], unsigned);
        minimum = Min(minimum, element);

V[d] = minimum<esize-1:0>;
```

# UMMLA

Unsigned integer matrix multiply-accumulate

The unsigned integer matrix multiply-accumulate instruction multiplies the 2×8 matrix of unsigned 8-bit integer values held in each 128-bit segment of the first source vector by the 8×2 matrix of unsigned 8-bit integer values in the corresponding segment of the second source vector. The resulting 2×2 widened 32-bit integer matrix product is then destructively added to the 32-bit integer matrix accumulator held in the corresponding segment of the addend and destination vector. This is equivalent to performing an 8-way dot product per destination element.

This instruction is unpredicated.

ID\_AA64ZFR0\_EL1.I8MM indicates whether this instruction is implemented.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	1	1	0	Zm				1	0	0	1	1	0	Zn				Zda						
uns<1>uns<0>																															

UMMLA <Zda>.S, <Zn>.B, <Zm>.B

```
if !HaveSVE() || !HaveInt8MatMulExt() then UNDEFINED;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean op1_unsigned = TRUE;
boolean op2_unsigned = TRUE;
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer segments = VL DIV 128;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result = Zeros();
bits(128) op1, op2;
bits(128) res, addend;

for s = 0 to segments-1
    op1 = Elem[operand1, s, 128];
    op2 = Elem[operand2, s, 128];
    addend = Elem[operand3, s, 128];
    res = MatMulAdd(addend, op1, op2, op1_unsigned, op2_unsigned);
    Elem[result, s, 128] = res;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

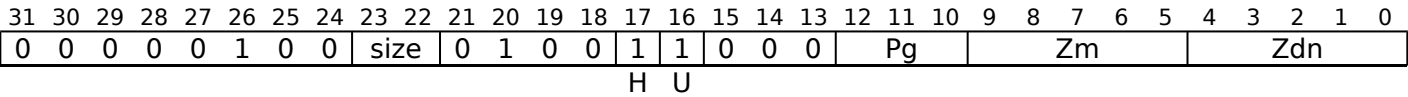
- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



# UMULH

Unsigned multiply returning high half (predicated)

Widening multiply unsigned integer values in active elements of the first source vector by corresponding elements of the second source vector and destructively place the high half of the result in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



UMULH <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean unsigned = TRUE;
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = if AnyActiveElement(mask, esize) then Z[m] else Zeros();
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    if ElemP[mask, e, esize] == '1' then
        integer product = (element1 * element2) >> esize;
        Elem[result, e, esize] = product<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

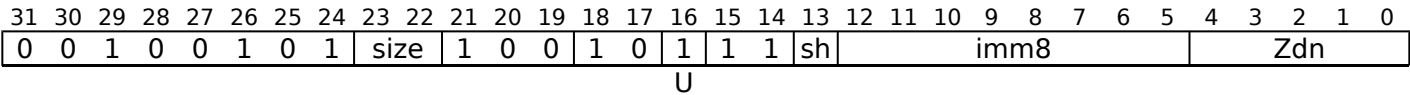
# UQADD (immediate)

Unsigned saturating add immediate (unpredicated)

Unsigned saturating add of an unsigned immediate to each element of the source vector, and destructively place the results in the corresponding elements of the source vector. Each result element is saturated to the N-bit element's unsigned integer range 0 to (2<sup>N</sup>)-1. This instruction is unpredicated.

The immediate is an unsigned value in the range 0 to 255, and for element widths of 16 bits or higher it may also be a positive multiple of 256 in the range 256 to 65280.

The immediate is encoded in 8 bits with an optional left shift by 8. The preferred disassembly when the shift option is specified is "#<uimm8>, LSL #8". However an assembler and disassembler may also allow use of the shifted 16-bit value unless the immediate is 0 and the shift amount is 8, which must be unambiguously described as "#0, LSL #8".



```
UQADD <Zdn>.<T>, <Zdn>.<T>, #<imm>{, <shift>}
```

```
if !HaveSVE() then UNDEFINED;
if size:sh == '001' then UNDEFINED;
integer esize = 8 << UInt(size);
integer dn = UInt(Zdn);
integer imm = UInt(imm8);
if sh == '1' then imm = imm << 8;
boolean unsigned = TRUE;
```

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<imm> Is an unsigned immediate in the range 0 to 255, encoded in the "imm8" field.

<shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #8

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 + imm, esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

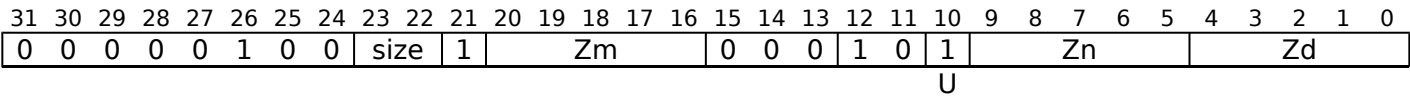
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



UQADD (vectors)

Unsigned saturating add vectors (unpredicated)

Unsigned saturating add all elements of the second source vector to corresponding elements of the first source vector and place the results in the corresponding elements of the destination vector. Each result element is saturated to the N-bit element's unsigned integer range 0 to (2<sup>N</sup>)-1. This instruction is unpredicated.



UQADD <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
boolean unsigned = TRUE;
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 + element2, esize, unsigned);

Z[d] = result;
```

# UQDECB

Unsigned saturating decrement scalar by multiple of 8-bit predicate constraint element count

Determines the number of active 8-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement the scalar destination. The result is saturated to the general-purpose register's unsigned integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	1	0	imm4				1	1	1	1	1	1	pattern					Rdn				
size<1>size<0>								sf			D U																				

UQDECB <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	1	1	imm4				1	1	1	1	1	1	pattern					Rdn				
size<1>size<0>								sf			D U																				

UQDECB <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 64;
```

## Assembler Symbols

- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 - (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# UQDECD (scalar)

Unsigned saturating decrement scalar by multiple of 64-bit predicate constraint element count

Determines the number of active 64-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement the scalar destination. The result is saturated to the general-purpose register's unsigned integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	1	1	0	imm4				1	1	1	1	1	1	pattern					Rdn				
size<1>size<0>								sf				D U																			

UQDECD <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	1	1	1	imm4				1	1	1	1	1	1	pattern					Rdn				
size<1>size<0>								sf			D U																				

UQDECD <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 64;
```

## Assembler Symbols

- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 - (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UQDECD (vector)

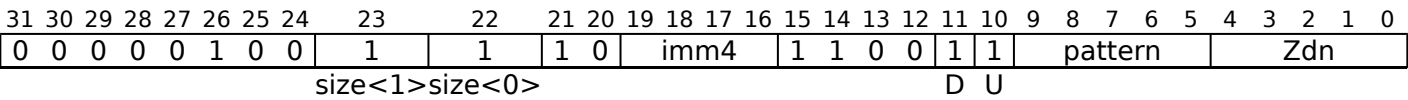
Unsigned saturating decrement vector by multiple of 64-bit predicate constraint element count

Determines the number of active 64-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement all destination vector elements. The results are saturated to the 64-bit unsigned integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.



UQDECD <Zdn>.D{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
```

Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer count = DecodePredCount(pat, esize);
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 - (count * imm), esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# UQDECH (scalar)

Unsigned saturating decrement scalar by multiple of 16-bit predicate constraint element count

Determines the number of active 16-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement the scalar destination. The result is saturated to the general-purpose register's unsigned integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1	0	imm4				1	1	1	1	1	1	pattern					Rdn				
size<1>size<0>								sf			D U																				

UQDECH <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1	1	imm4				1	1	1	1	1	1	pattern					Rdn				
size<1>size<0>								sf			D U																				

UQDECH <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 64;
```

## Assembler Symbols

- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":



pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 - (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UQDECH (vector)

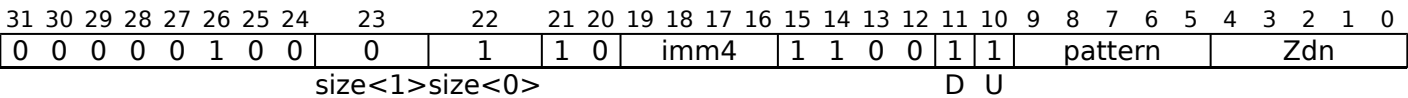
Unsigned saturating decrement vector by multiple of 16-bit predicate constraint element count

Determines the number of active 16-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement all destination vector elements. The results are saturated to the 16-bit unsigned integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.



UQDECH <Zdn>.H{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
```

Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer count = DecodePredCount(pat, esize);
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 - (count * imm), esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# UQDECP (scalar)

Unsigned saturating decrement scalar by count of true predicate elements

Counts the number of true elements in the source predicate and then uses the result to decrement the scalar destination. The result is saturated to the general-purpose register's unsigned integer range.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	0	1	0	1	1	1	0	0	0	1	0	0	Pm	Rdn								
D U														sf																	

UQDECP <Wdn>, <Pm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Rdn);
boolean unsigned = TRUE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	0	1	0	1	1	1	0	0	0	1	1	0	Pm			Rdn						
D U														sf																	

UQDECP <Xdn>, <Pm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Rdn);
boolean unsigned = TRUE;
integer ssize = 64;
```

## Assembler Symbols

- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Pm> Is the name of the source scalable predicate register, encoded in the "Pm" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(ssize) operand1 = X[dn];
bits(PL) operand2 = P[m];
bits(ssize) result;
integer count = 0;

for e = 0 to elements-1
    if ElemP[operand2, e, esize] == '1' then
        count = count + 1;

integer element = Int(operand1, unsigned);
(result, -) = Sat0(element - count, ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);
```

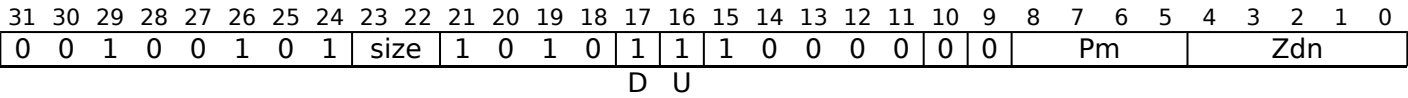
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# UQDECP (vector)

Unsigned saturating decrement vector by count of true predicate elements

Counts the number of true elements in the source predicate and then uses the result to decrement all destination vector elements. The results are saturated to the element unsigned integer range.  
The predicate size specifier may be omitted in assembler source code, but this is deprecated and will be prohibited in a future release of the architecture.



UQDECP <Zdn>.<T>, <Pm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Zdn);
boolean unsigned = TRUE;
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pm> Is the name of the source scalable predicate register, encoded in the "Pm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(PL) operand2 = P[m];
bits(VL) result;
integer count = 0;

for e = 0 to elements-1
    if ElemP[operand2, e, esize] == '1' then
        count = count + 1;

for e = 0 to elements-1
    integer element = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = Sat0(element - count, esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# UQDECW (scalar)

Unsigned saturating decrement scalar by multiple of 32-bit predicate constraint element count

Determines the number of active 32-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement the scalar destination. The result is saturated to the general-purpose register's unsigned integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	0	1	0	imm4				1	1	1	1	1	1	pattern					Rdn				
size<1>size<0>								sf			D U																				

UQDECW <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	0	1	1	imm4				1	1	1	1	1	1	pattern					Rdn				
size<1>size<0>								sf			D U																				

UQDECW <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 64;
```

## Assembler Symbols

- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":



pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 - (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UQDECW (vector)

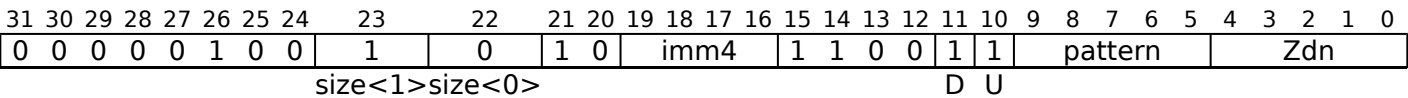
Unsigned saturating decrement vector by multiple of 32-bit predicate constraint element count

Determines the number of active 32-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement all destination vector elements. The results are saturated to the 32-bit unsigned integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.



UQDECW <Zdn>.S{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
```

Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer count = DecodePredCount(pat, esize);
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 - (count * imm), esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# UQINCB

Unsigned saturating increment scalar by multiple of 8-bit predicate constraint element count

Determines the number of active 8-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment the scalar destination. The result is saturated to the general-purpose register's unsigned integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	1	0	imm4				1	1	1	1	0	1	pattern					Rdn				
size<1>size<0>								sf			D U																				

UQINCB <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	1	1	imm4				1	1	1	1	0	1	pattern					Rdn				
size<1>size<0>								sf			D U																				

UQINCB <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 64;
```

## Assembler Symbols

- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 + (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# UQINCD (scalar)

Unsigned saturating increment scalar by multiple of 64-bit predicate constraint element count

Determines the number of active 64-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment the scalar destination. The result is saturated to the general-purpose register's unsigned integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	1	1	0	imm4				1	1	1	1	0	1	pattern					Rdn				
size<1>size<0>								sf			D U																				

UQINCD <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	1	1	1	imm4				1	1	1	1	0	1	pattern					Rdn				
size<1>size<0>								sf			D		U																		

UQINCD <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 64;
```

## Assembler Symbols

- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 + (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UQINCD (vector)

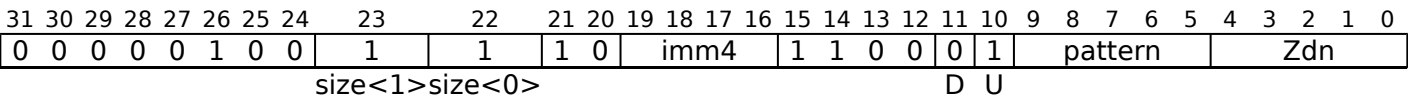
Unsigned saturating increment vector by multiple of 64-bit predicate constraint element count

Determines the number of active 64-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment all destination vector elements. The results are saturated to the 64-bit unsigned integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.



```
UQINCD <Zdn>.D{, <pattern>{, MUL #<imm>}}
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
```

Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer count = DecodePredCount(pat, esize);
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 + (count * imm), esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# UQINCH (scalar)

Unsigned saturating increment scalar by multiple of 16-bit predicate constraint element count

Determines the number of active 16-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment the scalar destination. The result is saturated to the general-purpose register's unsigned integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1	0	imm4				1	1	1	1	0	1	pattern					Rdn				
size<1>size<0>								sf			D U																				

UQINCH <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1	1	imm4				1	1	1	1	0	1	pattern					Rdn				
size<1>size<0>								sf			D U																				

UQINCH <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 64;
```

## Assembler Symbols

- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 + (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UQINCH (vector)

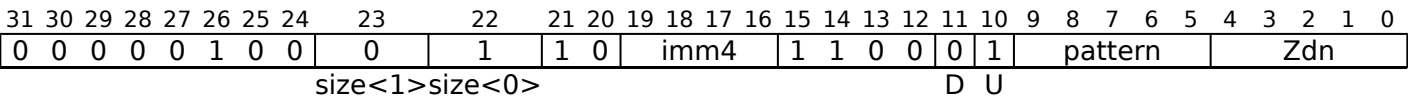
Unsigned saturating increment vector by multiple of 16-bit predicate constraint element count

Determines the number of active 16-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment all destination vector elements. The results are saturated to the 16-bit unsigned integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.



UQINCH <Zdn>.H{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
```

Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer count = DecodePredCount(pat, esize);
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 + (count * imm), esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# UQINCP (scalar)

Unsigned saturating increment scalar by count of true predicate elements

Counts the number of true elements in the source predicate and then uses the result to increment the scalar destination. The result is saturated to the general-purpose register's unsigned integer range.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	0	1	0	0	1	1	0	0	0	1	0	0	0	Pm			Rdn					
D U														sf																	

UQINCP <Wdn>, <Pm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Rdn);
boolean unsigned = TRUE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size		1	0	1	0	0	1	1	0	0	0	1	1	0	Pm			Rdn					
D U														sf																	

UQINCP <Xdn>, <Pm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Rdn);
boolean unsigned = TRUE;
integer ssize = 64;
```

## Assembler Symbols

- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Pm> Is the name of the source scalable predicate register, encoded in the "Pm" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(ssize) operand1 = X[dn];
bits(PL) operand2 = P[m];
bits(ssize) result;
integer count = 0;

for e = 0 to elements-1
    if ElemP[operand2, e, esize] == '1' then
        count = count + 1;

integer element = Int(operand1, unsigned);
(result, -) = Sat0(element + count, ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);
```

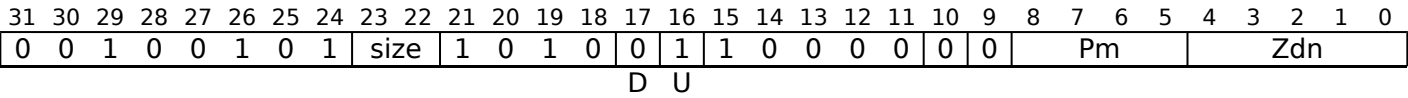
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# UQINCP (vector)

Unsigned saturating increment vector by count of true predicate elements

Counts the number of true elements in the source predicate and then uses the result to increment all destination vector elements. The results are saturated to the element unsigned integer range.  
The predicate size specifier may be omitted in assembler source code, but this is deprecated and will be prohibited in a future release of the architecture.



UQINCP <Zdn>.<T>, <Pm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Zdn);
boolean unsigned = TRUE;
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pm> Is the name of the source scalable predicate register, encoded in the "Pm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(PL) operand2 = P[m];
bits(VL) result;
integer count = 0;

for e = 0 to elements-1
    if ElemP[operand2, e, esize] == '1' then
        count = count + 1;

for e = 0 to elements-1
    integer element = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element + count, esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.



- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# UQINCW (scalar)

Unsigned saturating increment scalar by multiple of 32-bit predicate constraint element count

Determines the number of active 32-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment the scalar destination. The result is saturated to the general-purpose register's unsigned integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	0	1	0	imm4				1	1	1	1	0	1	pattern					Rdn				
size<1>size<0>								sf			D U																				

UQINCW <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	0	1	1	imm4				1	1	1	1	0	1	pattern					Rdn				
size<1>size<0>								sf			D U																				

UQINCW <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 64;
```

## Assembler Symbols

- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 + (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UQINCW (vector)

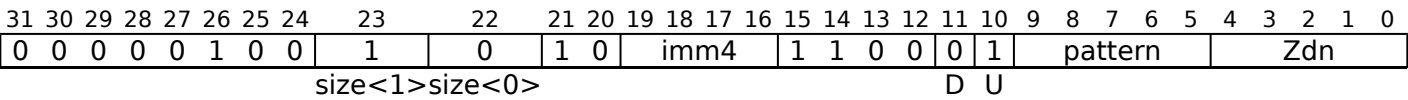
Unsigned saturating increment vector by multiple of 32-bit predicate constraint element count

Determines the number of active 32-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment all destination vector elements. The results are saturated to the 32-bit unsigned integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.



UQINCW <Zdn>.S{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
```

Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer count = DecodePredCount(pat, esize);
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 + (count * imm), esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

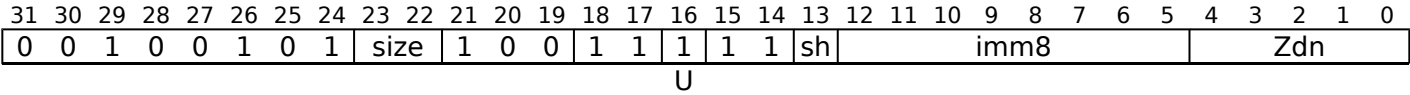
# UQSUB (immediate)

Unsigned saturating subtract immediate (unpredicated)

Unsigned saturating subtract an unsigned immediate from each element of the source vector, and destructively place the results in the corresponding elements of the source vector. Each result element is saturated to the N-bit element's unsigned integer range 0 to (2<sup>N</sup>)-1. This instruction is unpredicated.

The immediate is an unsigned value in the range 0 to 255, and for element widths of 16 bits or higher it may also be a positive multiple of 256 in the range 256 to 65280.

The immediate is encoded in 8 bits with an optional left shift by 8. The preferred disassembly when the shift option is specified is "#<uimm8>, LSL #8". However an assembler and disassembler may also allow use of the shifted 16-bit value unless the immediate is 0 and the shift amount is 8, which must be unambiguously described as "#0, LSL #8".



UQSUB <Zdn>.<T>, <Zdn>.<T>, #<imm>{, <shift>}

```
if !HaveSVE() then UNDEFINED;
if size:sh == '001' then UNDEFINED;
integer esize = 8 << UInt(size);
integer dn = UInt(Zdn);
integer imm = UInt(imm8);
if sh == '1' then imm = imm << 8;
boolean unsigned = TRUE;
```

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<imm> Is an unsigned immediate in the range 0 to 255, encoded in the "imm8" field.

<shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #8

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 - imm, esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

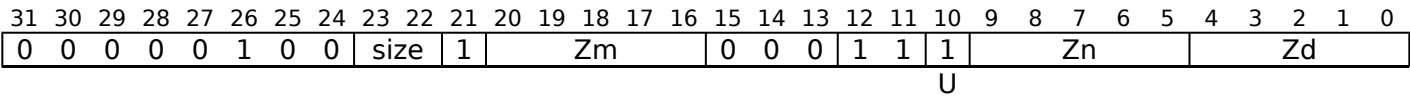
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

UQSUB (vectors)

Unsigned saturating subtract vectors (unpredicated)

Unsigned saturating subtract all elements of the second source vector from corresponding elements of the first source vector and place the results in the corresponding elements of the destination vector. Each result element is saturated to the N-bit element's unsigned integer range 0 to (2<sup>N</sup>)-1. This instruction is unpredicated.



UQSUB <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
boolean unsigned = TRUE;
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    (Elem[result, e, esize], -) = Sat0(element1 - element2, esize, unsigned);

Z[d] = result;
```



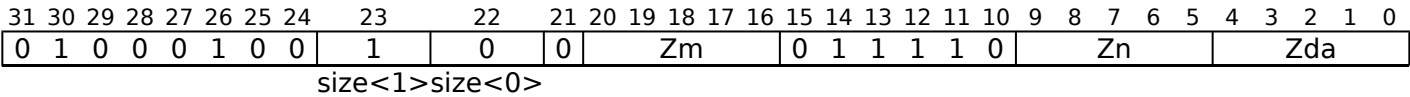
# USDOT (vectors)

Unsigned by signed integer dot product

The unsigned by signed integer dot product instruction computes the dot product of a group of four unsigned 8-bit integer values held in each 32-bit element of the first source vector multiplied by a group of four signed 8-bit integer values in the corresponding 32-bit element of the second source vector, and then destructively adds the widened dot product to the corresponding 32-bit element of the destination vector.

This instruction is unpredicated.

ID\_AA64ZFR0\_EL1.I8MM indicates whether this instruction is implemented.



USDOT <Zda>.S, <Zn>.B, <Zm>.B

```
if !HaveSVE() || !HaveInt8MatMulExt() then UNDEFINED;
integer esize = 32;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) res = Elem[operand3, e, esize];
    for i = 0 to 3
        integer element1 = UInt(Elem[operand1, 4 * e + i, esize DIV 4]);
        integer element2 = SInt(Elem[operand2, 4 * e + i, esize DIV 4]);
        res = res + element1 * element2;
    Elem[result, e, esize] = res;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

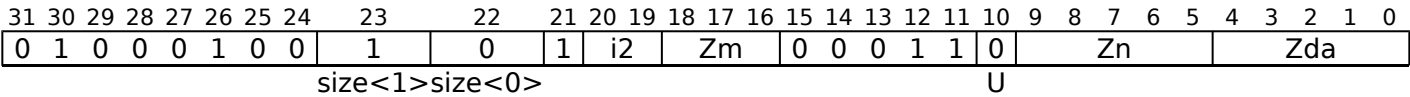
Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# USDOT (indexed)

Unsigned by signed integer indexed dot product

The unsigned by signed integer indexed dot product instruction computes the dot product of a group of four unsigned 8-bit integer values held in each 32-bit element of the first source vector multiplied by a group of four signed 8-bit integer values in an indexed 32-bit element of the second source vector, and then destructively adds the widened dot product to the corresponding 32-bit element of the destination vector.

The groups within the second source vector are specified using an immediate index which selects the same group position within each 128-bit vector segment. The index range is from 0 to 3. This instruction is unpredicated. ID\_AA64ZFR0\_EL1.I8MM indicates whether this instruction is implemented.



USDOT <Zda>.S, <Zn>.B, <Zm>.B[<imm>]

```
if !HaveSVE() || !HaveInt8MatMulExt() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.
- <imm> Is the immediate index of a quadruplet of four 8-bit elements within each 128-bit vector segment, in the range 0 to 3, encoded in the "i2" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer eltsperssegment = 128 DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltsperssegment);
    integer s = segmentbase + index;
    bits(esize) res = Elem[operand3, e, esize];
    for i = 0 to 3
        integer element1 = UInt(Elem[operand1, 4 * e + i, esize DIV 4]);
        integer element2 = SInt(Elem[operand2, 4 * s + i, esize DIV 4]);
        res = res + element1 * element2;
    Elem[result, e, esize] = res;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.

- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

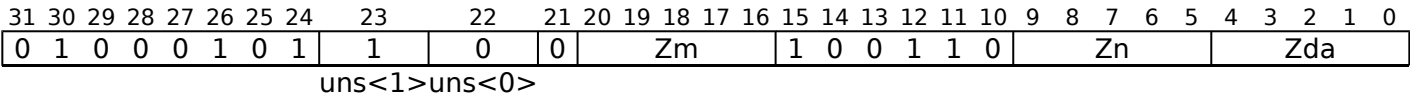
# USMMLA

Unsigned by signed integer matrix multiply-accumulate

The unsigned by signed integer matrix multiply-accumulate instruction multiplies the 2×8 matrix of unsigned 8-bit integer values held in each 128-bit segment of the first source vector by the 8×2 matrix of signed 8-bit integer values in the corresponding segment of the second source vector. The resulting 2×2 widened 32-bit integer matrix product is then destructively added to the 32-bit integer matrix accumulator held in the corresponding segment of the addend and destination vector. This is equivalent to performing an 8-way dot product per destination element.

This instruction is unpredicated.

ID\_AA64ZFR0\_EL1.I8MM indicates whether this instruction is implemented.



USMMLA <Zda>.S, <Zn>.B, <Zm>.B

```
if !HaveSVE() || !HaveInt8MatMulExt() then UNDEFINED;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean op1_unsigned = TRUE;
boolean op2_unsigned = FALSE;
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer segments = VL DIV 128;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result = Zeros();
bits(128) op1, op2;
bits(128) res, addend;

for s = 0 to segments-1
    op1 = Elem[operand1, s, 128];
    op2 = Elem[operand2, s, 128];
    addend = Elem[operand3, s, 128];
    res = MatMulAdd(addend, op1, op2, op1_unsigned, op2_unsigned);
    Elem[result, s, 128] = res;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



# UUNPKHI, UUNPKLO

Unsigned unpack and extend half of vector

Unpack elements from the lowest or highest half of the source vector and then zero-extend them to place in elements of twice their size within the destination vector. This instruction is unpredicated.

It has encodings from 2 classes: [High half](#) and [Low half](#)

## High half

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	1	0	0	1	1	0	0	1	1	1	0	Zn				Zd						
														U	H																

UUNPKHI <Zd>.<T>, <Zn>.<Tb>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean unsigned = TRUE;
boolean hi = TRUE;
```

## Low half

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	1	0	0	1	0	0	0	1	1	1	0	Zn				Zd						
														U	H																

UUNPKLO <Zd>.<T>, <Zn>.<Tb>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean unsigned = TRUE;
boolean hi = FALSE;
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
integer hsize = esize DIV 2;
bits(VL) operand = Z[n];
bits(VL) result;

for e = 0 to elements-1
    bits(hsize) element = if hi then Elem[operand, e + elements, hsize] else Elem[operand, e, hsize];
    Elem[result, e, esize] = Extend(element, esize, unsigned);

Z[d] = result;

```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# UXTB, UXTH, UXTW

Unsigned byte / halfword / word extend (predicated)

Zero-extend the least-significant sub-element of each active element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

It has encodings from 3 classes: [Byte](#) , [Halfword](#) and [Word](#)

## Byte

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	0	0	0	0	1	1	0	1	Pg			Zn					Zd				
U																															

UXTB <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer s_esize = 8;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean unsigned = TRUE;
```

## Halfword

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	0	0	1	1	1	0	1	Pg													
																U															

UXTH <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size != '1x' then UNDEFINED;
integer esize = 8 << UInt(size);
integer s_esize = 16;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean unsigned = TRUE;
```

## Word

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	0	1	0	1	1	0	1	Pg													
																U															

UXTW <Zd>.<D>, <Pg>/M, <Zn>.<D>

```
if !HaveSVE() then UNDEFINED;
if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer s_esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean unsigned = TRUE;
```



Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> For the byte variant: is the size specifier, encoded in “size”:

size	<T>
00	RESERVED
01	H
10	S
11	D

For the halfword variant: is the size specifier, encoded in “size<0>”:

size<0>	<T>
0	S
1	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = if AnyActiveElement(mask, esize) then Z[n] else Zeros();
bits(VL) result = Z[d];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element = Elem[operand, e, esize];
        Elem[result, e, esize] = Extend(element<s_esign-1:0>, esize, unsigned);

Z[d] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

## UZP1, UZP2 (predicates)

Concatenate even or odd elements from two predicates

Concatenate adjacent even or odd-numbered elements from the first and second source predicates and place in elements of the destination predicate. This instruction is unpredicated.

It has encodings from 2 classes: [Even](#) and [Odd](#)

### Even

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	Pm				0	1	0	0	1	0	0	Pn				0	Pd				
																H															

UZP1 [<Pd>.<T>](#), [<Pn>.<T>](#), [<Pm>.<T>](#)

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
integer part = 0;
```

### Odd

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	Pm				0	1	0	0	1	1	0	Pn				0	Pd				
H																															

UZP2 [<Pd>.<T>](#), [<Pn>.<T>](#), [<Pm>.<T>](#)

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
integer part = 1;
```

### Assembler Symbols

- <Pd>

Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <Pn>

Is the name of the first source scalable predicate register, encoded in the "Pn" field.
- <Pm>

Is the name of the second source scalable predicate register, encoded in the "Pm" field.

## Operation

```
CheckSVEEnabled();
integer pairs = VL DIV (esize * 2);
bits(PL) operand1 = P[n];
bits(PL) operand2 = P[m];
bits(PL) result;

for p = 0 to pairs - 1
    Elem[result, p, esize DIV 8] = Elem[operand1, 2*p+part, esize DIV 8];

for p = 0 to pairs - 1
    Elem[result, pairs+p, esize DIV 8] = Elem[operand2, 2*p+part, esize DIV 8];

P[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# UZP1, UZP2 (vectors)

Concatenate even or odd elements from two vectors

Concatenate adjacent even or odd-numbered elements from the first and second source vectors and place in elements of the destination vector. This instruction is unpredicated. The 128-bit element variant of this instruction requires that the current vector length is at least 256 bits, and if the current vector length is not an integer multiple of 256 bits then the trailing bits are set to zero.

ID\_AA64ZFR0\_EL1.F64MM indicates whether the 128-bit element variant of the instruction is implemented.

It has encodings from 4 classes: [Even](#) , [Even \(quadwords\)](#) , [Odd](#) and [Odd \(quadwords\)](#)

## Even

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	Zm						0	1	1	0	1	0	Zn						Zd			
																										H					

UZP1 <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer part = 0;
```

## Even (quadwords)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	1	0	1	Zm				0			0	0	0	1	0	Zn				Zd				
																										H					

UZP1 <Zd>.Q, <Zn>.Q, <Zm>.Q

```
if !HaveSVEFP64MatMulExt() then UNDEFINED;
integer esize = 128;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer part = 0;
```

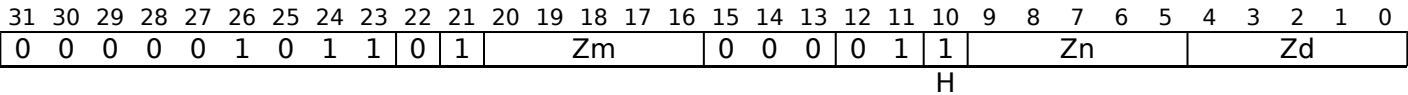
## Odd

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	Zm			0	1	1	0	1	1	Zn			Zd									
																										H					

UZP2 <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer part = 1;
```

Odd (quadwords)



```
UZP2 <Zd>.Q, <Zn>.Q, <Zm>.Q
```

```
if !HaveSVEFP64MatMulExt() then UNDEFINED;
integer esize = 128;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer part = 1;
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
if VL < esize * 2 then UNDEFINED;
integer pairs = VL DIV (esize * 2);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Zeros();

for p = 0 to pairs - 1
    Elem[result, p, esize] = Elem[operand1, 2*p+part, esize];

for p = 0 to pairs - 1
    Elem[result, pairs+p, esize] = Elem[operand2, 2*p+part, esize];

Z[d] = result;
```

WHILELE

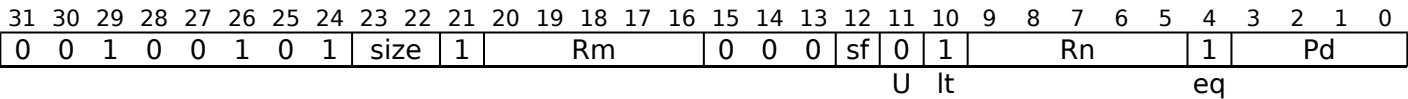
While incrementing signed scalar less than or equal to scalar

Generate a predicate that starting from the lowest numbered element is true while the incrementing value of the first, signed scalar operand is less than or equal to the second scalar operand and false thereafter up to the highest numbered element.

If the second scalar operand is equal to the maximum signed integer value then a condition which includes an equality test can never fail and the result will be an all-true predicate.

The full width of the scalar operands is significant for the purposes of comparison, and the full width first operand is incremented by one for each destination predicate element, irrespective of the predicate result element size. The first general-purpose source register is not itself updated.

The predicate result is placed in the predicate destination register. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.



WHILELE <Pd>.<T>, <R><n>, <R><m>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer rsize = 32 << UInt(sf);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Pd);
boolean unsigned = FALSE;
SVEComp op = Cmp_LE;
```

Assembler Symbols

<Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<R> Is a width specifier, encoded in "sf":

sf	<R>
0	W
1	X

<n> Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rn" field.

<m> Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = Ones(PL);
bits(rsize) operand1 = X[n];
bits(rsize) operand2 = X[m];
bits(PL) result;
boolean last = TRUE;

for e = 0 to elements-1
    boolean cond;
    case op of
        when Cmp_LT cond = (Int(operand1, unsigned) < Int(operand2, unsigned));
        when Cmp_LE cond = (Int(operand1, unsigned) <= Int(operand2, unsigned));

    last = last && cond;
    ElemP[result, e, esize] = if last then '1' else '0';
    operand1 = operand1 + 1;

PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

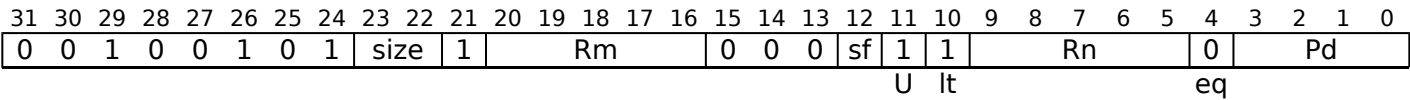
WHILELO

While incrementing unsigned scalar lower than scalar

Generate a predicate that starting from the lowest numbered element is true while the incrementing value of the first, unsigned scalar operand is lower than the second scalar operand and false thereafter up to the highest numbered element.

The full width of the scalar operands is significant for the purposes of comparison, and the full width first operand is incremented by one for each destination predicate element, irrespective of the predicate result element size. The first general-purpose source register is not itself updated.

The predicate result is placed in the predicate destination register. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.



WHILELO <Pd>.<T>, <R><n>, <R><m>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer rsize = 32 << UInt(sf);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Pd);
boolean unsigned = TRUE;
SVEComp op = Cmp_LT;
```

Assembler Symbols

- <Pd>

Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <R>

Is a width specifier, encoded in "sf":

sf	<R>
0	W
1	X
- <n>

Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rn" field.
- <m>

Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rm" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = Ones(PL);
bits(rsize) operand1 = X[n];
bits(rsize) operand2 = X[m];
bits(PL) result;
boolean last = TRUE;

for e = 0 to elements-1
    boolean cond;
    case op of
        when Cmp_LT cond = (Int(operand1, unsigned) < Int(operand2, unsigned));
        when Cmp_LE cond = (Int(operand1, unsigned) <= Int(operand2, unsigned));

    last = last && cond;
    ElemP[result, e, esize] = if last then '1' else '0';
    operand1 = operand1 + 1;

PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

WHILELS

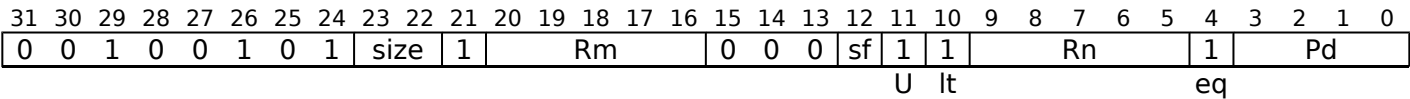
While incrementing unsigned scalar lower or same as scalar

Generate a predicate that starting from the lowest numbered element is true while the incrementing value of the first, unsigned scalar operand is lower or same as the second scalar operand and false thereafter up to the highest numbered element.

If the second scalar operand is equal to the maximum unsigned integer value then a condition which includes an equality test can never fail and the result will be an all-true predicate.

The full width of the scalar operands is significant for the purposes of comparison, and the full width first operand is incremented by one for each destination predicate element, irrespective of the predicate result element size. The first general-purpose source register is not itself updated.

The predicate result is placed in the predicate destination register. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.



WHILELS <Pd>.<T>, <R><n>, <R><m>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer rsize = 32 << UInt(sf);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Pd);
boolean unsigned = TRUE;
SVEComp op = Cmp_LE;
```

Assembler Symbols

<Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<R> Is a width specifier, encoded in "sf":

sf	<R>
0	W
1	X

<n> Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rn" field.

<m> Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = Ones(PL);
bits(rsize) operand1 = X[n];
bits(rsize) operand2 = X[m];
bits(PL) result;
boolean last = TRUE;

for e = 0 to elements-1
    boolean cond;
    case op of
        when Cmp_LT cond = (Int(operand1, unsigned) < Int(operand2, unsigned));
        when Cmp_LE cond = (Int(operand1, unsigned) <= Int(operand2, unsigned));

    last = last && cond;
    ElemP[result, e, esize] = if last then '1' else '0';
    operand1 = operand1 + 1;

PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

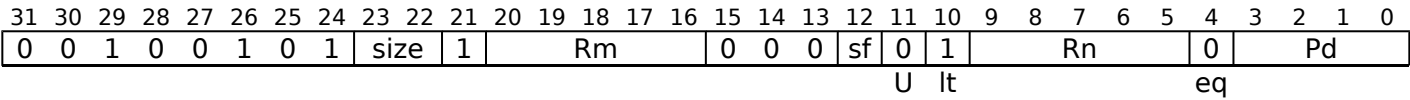
Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# WHILELT

While incrementing signed scalar less than scalar

Generate a predicate that starting from the lowest numbered element is true while the incrementing value of the first, signed scalar operand is less than the second scalar operand and false thereafter up to the highest numbered element. The full width of the scalar operands is significant for the purposes of comparison, and the full width first operand is incremented by one for each destination predicate element, irrespective of the predicate result element size. The first general-purpose source register is not itself updated. The predicate result is placed in the predicate destination register. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.



WHILELT <Pd>.<T>, <R><n>, <R><m>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer rsize = 32 << UInt(sf);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Pd);
boolean unsigned = FALSE;
SVEComp op = Cmp_LT;
```

## Assembler Symbols

- <Pd>

Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <R>

Is a width specifier, encoded in "sf":

sf	<R>
0	W
1	X
- <n>

Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rn" field.
- <m>

Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = Ones(PL);
bits(rsize) operand1 = X[n];
bits(rsize) operand2 = X[m];
bits(PL) result;
boolean last = TRUE;

for e = 0 to elements-1
    boolean cond;
    case op of
        when Cmp_LT cond = (Int(operand1, unsigned) < Int(operand2, unsigned));
        when Cmp_LE cond = (Int(operand1, unsigned) <= Int(operand2, unsigned));

    last = last && cond;
    ElemP[result, e, esize] = if last then '1' else '0';
    operand1 = operand1 + 1;

PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

# WRFFR

Write the first-fault register

Read the source predicate register and place in the first-fault register (FFR). This instruction is intended to restore a saved FFR and is not recommended for general use by applications.

This instruction requires that the source predicate contains a MONOTONIC predicate value, in which starting from bit 0 there are zero or more 1 bits, followed only by 0 bits in any remaining bit positions. If the source is not a monotonic predicate value, then the resulting value in the FFR will be UNPREDICTABLE. It is not possible to generate a non-monotonic value in FFR when using SETFFR followed by first-fault or non-fault loads.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	0	1	0	1	0	0	0	1	0	0	1	0	0	0	Pn			0	0	0	0	0	

WRFFR <Pn>.B

```
if !HaveSVE() then UNDEFINED;
integer n = UInt(Pn);
```

## Assembler Symbols

<Pn> Is the name of the source scalable predicate register, encoded in the "Pn" field.

## Operation

```
CheckSVEEnabled();
bits(PL) operand = P[n];

hsb = HighestSetBit(operand);
if hsb < 0 || IsOnes(operand<hsb:0>) then
    FFR[] = operand;
else // not a monotonic predicate
    FFR[] = bits(PL) UNKNOWN;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## ZIP1, ZIP2 (predicates)

Interleave elements from two half predicates

Interleave alternating elements from the lowest or highest halves of the first and second source predicates and place in elements of the destination predicate. This instruction is unpredicated.

It has encodings from 2 classes: [High halves](#) and [Low halves](#)

### High halves

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	Pm				0	1	0	0	0	1	0	Pn				0	Pd				
																H															

ZIP2 [<Pd>.<T>](#), [<Pn>.<T>](#), [<Pm>.<T>](#)

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
integer part = 1;
```

### Low halves

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	Pm				0	1	0	0	0	0	0	Pn				0	Pd				
																H															

ZIP1 [<Pd>.<T>](#), [<Pn>.<T>](#), [<Pm>.<T>](#)

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
integer part = 0;
```

### Assembler Symbols

- <Pd>

Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <Pn>

Is the name of the first source scalable predicate register, encoded in the "Pn" field.
- <Pm>

Is the name of the second source scalable predicate register, encoded in the "Pm" field.

## Operation

```
CheckSVEEnabled();
integer pairs = VL DIV (esize * 2);
bits(PL) operand1 = P[n];
bits(PL) operand2 = P[m];
bits(PL) result;

integer base = part * pairs;
for p = 0 to pairs-1
    Elem[result, 2*p+0, esize DIV 8] = Elem[operand1, base+p, esize DIV 8];
    Elem[result, 2*p+1, esize DIV 8] = Elem[operand2, base+p, esize DIV 8];

P[d] = result;
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.



## ZIP1, ZIP2 (vectors)

Interleave elements from two half vectors

Interleave alternating elements from the lowest or highest halves of the first and second source vectors and place in elements of the destination vector. This instruction is unpredicated. The 128-bit element variant of this instruction requires that the current vector length is at least 256 bits, and if the current vector length is not an integer multiple of 256 bits then the trailing bits are set to zero.

ID\_AA64ZFR0\_EL1.F64MM indicates whether the 128-bit element variant of the instruction is implemented.

It has encodings from 4 classes: [High halves](#) , [High halves \(quadwords\)](#) , [Low halves](#) and [Low halves \(quadwords\)](#)

### High halves

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	Zm						0	1	1	0	0	1	Zn						Zd			
																										H					

ZIP2 [<Zd>.<T>](#), [<Zn>.<T>](#), [<Zm>.<T>](#)

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer part = 1;
```

### High halves (quadwords)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	1	0	1	Zm				0	0	0	0	0	1	Zn				Zd						
																										H					

ZIP2 [<Zd>.Q](#), [<Zn>.Q](#), [<Zm>.Q](#)

```
if !HaveSVEFP64MatMulExt() then UNDEFINED;
integer esize = 128;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer part = 1;
```

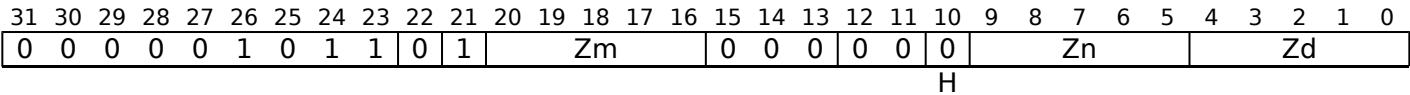
### Low halves

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	Zm						0	1	1	0	0	0	Zn						Zd			
																										H					

ZIP1 [<Zd>.<T>](#), [<Zn>.<T>](#), [<Zm>.<T>](#)

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer part = 0;
```

Low halves (quadwords)



```
ZIP1 <Zd>.Q, <Zn>.Q, <Zm>.Q
```

```
if !HaveSVEFP64MatMulExt() then UNDEFINED;
integer esize = 128;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer part = 0;
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
if VL < esize * 2 then UNDEFINED;
integer pairs = VL DIV (esize * 2);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Zeros();

integer base = part * pairs;
for p = 0 to pairs-1
    Elem[result, 2*p+0, esize] = Elem[operand1, base+p, esize];
    Elem[result, 2*p+1, esize] = Elem[operand2, base+p, esize];

Z[d] = result;
```

## Top-level encodings for A64

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
			op0																												

Decode fields op0	Instruction details
0000	<a href="#">Reserved</a>
0001	UNALLOCATED
0010	<a href="#">SVE encodings</a>
0011	UNALLOCATED
100x	<a href="#">Data Processing -- Immediate</a>
101x	<a href="#">Branches, Exception Generating and System instructions</a>
x1x0	<a href="#">Loads and Stores</a>
x101	<a href="#">Data Processing -- Register</a>
x111	<a href="#">Data Processing -- Scalar Floating-Point and Advanced SIMD</a>

### Reserved

These instructions are under the [top-level](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
op0				0000				op1																							

Decode fields op0	Decode fields op1	Instruction details
000	000000000	<a href="#">UDF</a>
	!= 000000000	UNALLOCATED
!= 000		UNALLOCATED

### SVE encodings

These instructions are under the [top-level](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
op0				0010				op1				op2				op3															

Decode fields op0	Decode fields op1	Decode fields op2	Decode fields op3	Instruction details
000	0x	0xxxx	x1xxxx	<a href="#">SVE Integer Multiply-Add - Predicated</a>
000	0x	0xxxx	000xxx	<a href="#">SVE Integer Binary Arithmetic - Predicated</a>
000	0x	0xxxx	001xxx	<a href="#">SVE Integer Reduction</a>
000	0x	0xxxx	100xxx	<a href="#">SVE Bitwise Shift - Predicated</a>
000	0x	0xxxx	101xxx	<a href="#">SVE Integer Unary Arithmetic - Predicated</a>
000	0x	1xxxx	000xxx	<a href="#">SVE integer add/subtract vectors (unpredicated)</a>
000	0x	1xxxx	001xxx	<a href="#">SVE Bitwise Logical - Unpredicated</a>
000	0x	1xxxx	0100xx	<a href="#">SVE Index Generation</a>
000	0x	1xxxx	0101xx	<a href="#">SVE Stack Allocation</a>
000	0x	1xxxx	011xxx	UNALLOCATED
000	0x	1xxxx	100xxx	<a href="#">SVE Bitwise Shift - Unpredicated</a>
000	0x	1xxxx	1010xx	<a href="#">SVE address generation</a>
000	0x	1xxxx	1011xx	<a href="#">SVE Integer Misc - Unpredicated</a>

000	0x	1xxxx	11xxxx	<a href="#">SVE Element Count</a>
000	1x	00xxx		<a href="#">SVE Bitwise Immediate</a>
000	1x	01xxx		<a href="#">SVE Integer Wide Immediate - Predicated</a>
000	1x	1xxxx	001000	<a href="#">DUP (indexed)</a>
000	1x	1xxxx	001001	UNALLOCATED
000	1x	1xxxx	00101x	UNALLOCATED
000	1x	1xxxx	0011x1	UNALLOCATED
000	1x	1xxxx	001100	<a href="#">TBL</a>
000	1x	1xxxx	001110	<a href="#">SVE Permute Vector - Unpredicated</a>
000	1x	1xxxx	010xxx	<a href="#">SVE Permute Predicate</a>
000	1x	1xxxx	011xxx	<a href="#">SVE permute vector elements</a>
000	1x	1xxxx	10xxxx	<a href="#">SVE Permute Vector - Predicated</a>
000	1x	1xxxx	11xxxx	<a href="#">SEL (vectors)</a>
000	10	1xxxx	000xxx	<a href="#">SVE Permute Vector - Extract</a>
000	11	1xxxx	000xxx	<a href="#">SVE permute vector segments</a>
001	0x	0xxxx		<a href="#">SVE Integer Compare - Vectors</a>
001	0x	1xxxx		<a href="#">SVE integer compare with unsigned immediate</a>
001	1x	0xxxx	x0xxxx	<a href="#">SVE integer compare with signed immediate</a>
001	1x	00xxx	01xxxx	<a href="#">SVE predicate logical operations</a>
001	1x	00xxx	11xxxx	<a href="#">SVE Propagate Break</a>
001	1x	01xxx	01xxxx	<a href="#">SVE Partition Break</a>
001	1x	01xxx	11xxxx	<a href="#">SVE Predicate Misc</a>
001	1x	1xxxx	00xxxx	<a href="#">SVE Integer Compare - Scalars</a>
001	1x	1xxxx	01xxxx	UNALLOCATED
001	1x	1xxxx	11xxxx	<a href="#">SVE Integer Wide Immediate - Unpredicated</a>
001	1x	100xx	10xxxx	<a href="#">SVE Predicate Count</a>
001	1x	101xx	1000xx	<a href="#">SVE Inc/Dec by Predicate Count</a>
001	1x	101xx	1001xx	<a href="#">SVE Write FFR</a>
001	1x	101xx	101xxx	UNALLOCATED
001	1x	11xxx	10xxxx	UNALLOCATED
010	0x	0xxxx	0xxxxxx	<a href="#">SVE Integer Multiply-Add - Unpredicated</a>
010	0x	0xxxx	1xxxxxx	UNALLOCATED
010	0x	1xxxx		<a href="#">SVE Multiply - Indexed</a>
010	1x	0xxxx	0xxxxxx	UNALLOCATED
010	1x	0xxxx	10xxxx	<a href="#">SVE Misc</a>
010	1x	0xxxx	11xxxx	UNALLOCATED
010	1x	1xxxx		UNALLOCATED
011	0x	0xxxx	0xxxxxx	<a href="#">FCMLA (vectors)</a>
011	0x	00x1x	1xxxxxx	UNALLOCATED
011	0x	00000	100xxx	<a href="#">FCADD</a>
011	0x	00000	101xxx	UNALLOCATED
011	0x	00000	11xxxx	UNALLOCATED
011	0x	00001	1xxxxxx	UNALLOCATED
011	0x	0010x	100xxx	UNALLOCATED
011	0x	0010x	101xxx	<a href="#">SVE floating-point convert precision odd elements</a>
011	0x	0010x	11xxxx	UNALLOCATED
011	0x	01xxx	1xxxxxx	UNALLOCATED
011	0x	1xxxx	x0x01x	UNALLOCATED
011	0x	1xxxx	00000x	<a href="#">SVE floating-point multiply-add (indexed)</a>

011	0x	1xxxx	0001xx	<a href="#">SVE floating-point complex multiply-add (indexed)</a>
011	0x	1xxxx	001000	<a href="#">SVE floating-point multiply (indexed)</a>
011	0x	1xxxx	001001	UNALLOCATED
011	0x	1xxxx	0011xx	UNALLOCATED
011	0x	1xxxx	01x0xx	<a href="#">SVE Floating Point Widening Multiply-Add - Indexed</a>
011	0x	1xxxx	01x1xx	UNALLOCATED
011	0x	1xxxx	10x00x	<a href="#">SVE Floating Point Widening Multiply-Add</a>
011	0x	1xxxx	10x1xx	UNALLOCATED
011	0x	1xxxx	110xxx	UNALLOCATED
011	0x	1xxxx	111000	UNALLOCATED
011	0x	1xxxx	111001	<a href="#">SVE floating point matrix multiply accumulate</a>
011	0x	1xxxx	11101x	UNALLOCATED
011	0x	1xxxx	1111xx	UNALLOCATED
011	1x	0xxxx	x1xxxx	<a href="#">SVE floating-point compare vectors</a>
011	1x	0xxxx	000xxx	<a href="#">SVE floating-point arithmetic (unpredicated)</a>
011	1x	0xxxx	100xxx	<a href="#">SVE Floating Point Arithmetic - Predicated</a>
011	1x	0xxxx	101xxx	<a href="#">SVE Floating Point Unary Operations - Predicated</a>
011	1x	000xx	001xxx	<a href="#">SVE floating-point recursive reduction</a>
011	1x	001xx	0010xx	UNALLOCATED
011	1x	001xx	0011xx	<a href="#">SVE Floating Point Unary Operations - Unpredicated</a>
011	1x	010xx	001xxx	<a href="#">SVE Floating Point Compare - with Zero</a>
011	1x	011xx	001xxx	<a href="#">SVE Floating Point Accumulating Reduction</a>
011	1x	1xxxx		<a href="#">SVE Floating Point Multiply-Add</a>
100				<a href="#">SVE Memory - 32-bit Gather and Unsized Contiguous</a>
101				<a href="#">SVE Memory - Contiguous Load</a>
110				<a href="#">SVE Memory - 64-bit Gather</a>
111			0x0xxx	<a href="#">SVE Memory - Contiguous Store and Unsized Contiguous</a>
111			0x1xxx	<a href="#">SVE Memory - Non-temporal and Multi-register Store</a>
111			1x0xxx	<a href="#">SVE Memory - Scatter with Optional Sign Extend</a>
111			101xxx	<a href="#">SVE Memory - Scatter</a>
111			111xxx	<a href="#">SVE Memory - Contiguous Store with Immediate Offset</a>

## SVE Integer Multiply-Add - Predicated

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0			0						op0	1														

### Decode fields

### Instruction details

0	<a href="#">SVE integer multiply-accumulate writing addend (predicated)</a>
1	<a href="#">SVE integer multiply-add writing multiplicand (predicated)</a>

## SVE integer multiply-accumulate writing addend (predicated)

These instructions are under [SVE Integer Multiply-Add - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0				Zm			0	1	op		Pg					Zn				Zda		

Decode fields op	Instruction Details
0	<a href="#">MLA</a>
1	<a href="#">MLS</a>

### SVE integer multiply-add writing multiplicand (predicated)

These instructions are under [SVE Integer Multiply-Add - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0			Zm		1	1	op		Pg						Za					Zdn		

Decode fields op	Instruction Details
0	<a href="#">MAD</a>
1	<a href="#">MSB</a>

### SVE Integer Binary Arithmetic - Predicated

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
						00000100			0	op0						000															

Decode fields op0	Instruction details
00x	<a href="#">SVE integer add/subtract vectors (predicated)</a>
01x	<a href="#">SVE integer min/max/difference (predicated)</a>
100	<a href="#">SVE integer multiply vectors (predicated)</a>
101	<a href="#">SVE integer divide vectors (predicated)</a>
11x	<a href="#">SVE bitwise logical operations (predicated)</a>

### SVE integer add/subtract vectors (predicated)

These instructions are under [SVE Integer Binary Arithmetic - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	0	0		opc		0	0	0		Pg					Zm					Zdn		

Decode fields opc	Instruction Details
000	<a href="#">ADD (vectors, predicated)</a>
001	<a href="#">SUB (vectors, predicated)</a>
010	UNALLOCATED
011	<a href="#">SUBR (vectors)</a>
1xx	UNALLOCATED

### SVE integer min/max/difference (predicated)

These instructions are under [SVE Integer Binary Arithmetic - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	0	1	opc	U	0	0	0		Pg						Zm					Zdn		

Decode fields opc	U	Instruction Details
00	0	<a href="#">SMAX (vectors)</a>
00	1	<a href="#">UMAX (vectors)</a>
01	0	<a href="#">SMIN (vectors)</a>
01	1	<a href="#">UMIN (vectors)</a>
10	0	<a href="#">SABD</a>
10	1	<a href="#">UABD</a>
11		UNALLOCATED

### SVE integer multiply vectors (predicated)

These instructions are under [SVE Integer Binary Arithmetic - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	0	0	H	U	0	0	0		Pg					Zm					Zdn		

Decode fields H	U	Instruction Details
0	0	<a href="#">MUL (vectors)</a>
0	1	UNALLOCATED
1	0	<a href="#">SMULH</a>
1	1	<a href="#">UMULH</a>

### SVE integer divide vectors (predicated)

These instructions are under [SVE Integer Binary Arithmetic - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	0	1	R	U	0	0	0		Pg					Zm					Zdn		

Decode fields R	U	Instruction Details
0	0	<a href="#">SDIV</a>
0	1	<a href="#">UDIV</a>
1	0	<a href="#">SDIVR</a>
1	1	<a href="#">UDIVR</a>

### SVE bitwise logical operations (predicated)

These instructions are under [SVE Integer Binary Arithmetic - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1		opc			0	0	0		Pg					Zm				Zdn		

Decode fields opc	Instruction Details
000	<a href="#">ORR (vectors, predicated)</a>
001	<a href="#">EOR (vectors, predicated)</a>
010	<a href="#">AND (vectors, predicated)</a>
011	<a href="#">BIC (vectors, predicated)</a>
1xx	UNALLOCATED

## SVE Integer Reduction

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00000100									0	op0						001															

Decode fields op0	Instruction details
000	<a href="#">SVE integer add reduction (predicated)</a>
010	<a href="#">SVE integer min/max reduction (predicated)</a>
0x1	UNALLOCATED
10x	<a href="#">SVE constructive prefix (predicated)</a>
110	<a href="#">SVE bitwise logical reduction (predicated)</a>
111	UNALLOCATED

### SVE integer add reduction (predicated)

These instructions are under [SVE Integer Reduction](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size		0	0	0	0	op	U	0	0	1	Pg			Zn			Vd						

Decode fields op	U	Instruction Details
0	0	<a href="#">SADDV</a>
0	1	<a href="#">UADDV</a>
1		UNALLOCATED

### SVE integer min/max reduction (predicated)

These instructions are under [SVE Integer Reduction](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size		0	0	1	0	op	U	0	0	1	Pg			Zn			Vd						

Decode fields op	U	Instruction Details
0	0	<a href="#">SMAV</a>
0	1	<a href="#">UMAV</a>
1	0	<a href="#">SMINV</a>
1	1	<a href="#">UMINV</a>

### SVE constructive prefix (predicated)

These instructions are under [SVE Integer Reduction](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	0	opc	M	0	0	1	Pg			Zn			Zd								

Decode fields opc	Instruction Details
00	<a href="#">MOVPRFX (predicated)</a>
01	UNALLOCATED
1x	UNALLOCATED



**SVE bitwise logical reduction (predicated)**

These instructions are under [SVE Integer Reduction](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	0	opc	0	0	1	Pg	Zn					Vd								

Decode fields opc	Instruction Details
00	<a href="#">ORV</a>
01	<a href="#">EORV</a>
10	<a href="#">ANDV</a>
11	UNALLOCATED

**SVE Bitwise Shift - Predicated**

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00000100									0	op0		100																			

Decode fields op0	Instruction details
0x	<a href="#">SVE bitwise shift by immediate (predicated)</a>
10	<a href="#">SVE bitwise shift by vector (predicated)</a>
11	<a href="#">SVE bitwise shift by wide elements (predicated)</a>

**SVE bitwise shift by immediate (predicated)**

These instructions are under [SVE Bitwise Shift - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	tszh	0	0	opc	L	U	1	0	0	Pg	tszl	imm3	Zdn											

Decode fields opc	L	U	Instruction Details
00	0	0	<a href="#">ASR (immediate, predicated)</a>
00	0	1	<a href="#">LSR (immediate, predicated)</a>
00	1	0	UNALLOCATED
00	1	1	<a href="#">LSL (immediate, predicated)</a>
01	0	0	<a href="#">ASRD</a>
01	0	1	UNALLOCATED
01	1		UNALLOCATED
1x			UNALLOCATED

**SVE bitwise shift by vector (predicated)**

These instructions are under [SVE Bitwise Shift - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	0	R	L	U	1	0	0	Pg	Zm				Zdn								

Decode fields R	L	U	Instruction Details
	1	0	UNALLOCATED
0	0	0	<a href="#">ASR (vectors)</a>

Decode fields			Instruction Details
R	L	U	
0	0	1	<a href="#">LSR (vectors)</a>
0	1	1	<a href="#">LSL (vectors)</a>
1	0	0	<a href="#">ASRR</a>
1	0	1	<a href="#">LSRR</a>
1	1	1	<a href="#">LSLR</a>

### SVE bitwise shift by wide elements (predicated)

These instructions are under [SVE Bitwise Shift - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	R	L	U	1	0	0	Pg			Zm					Zdn					

Decode fields			Instruction Details
R	L	U	
0	0	0	<a href="#">ASR (wide elements, predicated)</a>
0	0	1	<a href="#">LSR (wide elements, predicated)</a>
0	1	0	UNALLOCATED
0	1	1	<a href="#">LSL (wide elements, predicated)</a>
1			UNALLOCATED

### SVE Integer Unary Arithmetic - Predicated

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00000100									0	op0	101																				

Decode fields		Instruction details
op0		
0x		UNALLOCATED
10		<a href="#">SVE integer unary operations (predicated)</a>
11		<a href="#">SVE bitwise unary operations (predicated)</a>

### SVE integer unary operations (predicated)

These instructions are under [SVE Integer Unary Arithmetic - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	0	opc	1	0	1	Pg	Zn			Zd											

Decode fields		Instruction Details
opc		
000		<a href="#">SXTB, SXTH, SXTW</a> — <a href="#">SXTB</a>
001		<a href="#">UXTB, UXTH, UXTW</a> — <a href="#">UXTB</a>
010		<a href="#">SXTB, SXTH, SXTW</a> — <a href="#">SXTH</a>
011		<a href="#">UXTB, UXTH, UXTW</a> — <a href="#">UXTH</a>
100		<a href="#">SXTB, SXTH, SXTW</a> — <a href="#">SXTW</a>
101		<a href="#">UXTB, UXTH, UXTW</a> — <a href="#">UXTW</a>
110		<a href="#">ABS</a>
111		<a href="#">NEG</a>

**SVE bitwise unary operations (predicated)**

These instructions are under [SVE Integer Unary Arithmetic - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	opc	1	0	1	Pg	Zn			Zd											

Decode fields opc	Instruction Details
000	<a href="#">CLS</a>
001	<a href="#">CLZ</a>
010	<a href="#">CNT</a>
011	<a href="#">CNOT</a>
100	<a href="#">FABS</a>
101	<a href="#">FNEG</a>
110	<a href="#">NOT (vector)</a>
111	UNALLOCATED

**SVE integer add/subtract vectors (unpredicated)**

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1	Zm			0	0	0	opc		Zn			Zd										

Decode fields opc	Instruction Details
000	<a href="#">ADD (vectors, unpredicated)</a>
001	<a href="#">SUB (vectors, unpredicated)</a>
01x	UNALLOCATED
100	<a href="#">SQADD (vectors)</a>
101	<a href="#">UQADD (vectors)</a>
110	<a href="#">SQSUB (vectors)</a>
111	<a href="#">UQSUB (vectors)</a>

**SVE Bitwise Logical - Unpredicated**

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00000100									1							001	op0	op1													

Decode fields op0	op1	Instruction details
0		UNALLOCATED
1	00	<a href="#">SVE bitwise logical operations (unpredicated)</a>
1	!= 00	UNALLOCATED

**SVE bitwise logical operations (unpredicated)**

These instructions are under [SVE Bitwise Logical - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	opc	1	Zm			0	0	1	1	0	0	Zn			Zd									

Decode fields opc	Instruction Details
00	<a href="#">AND (vectors, unpredicated)</a>
01	<a href="#">ORR (vectors, unpredicated)</a>
10	<a href="#">EOR (vectors, unpredicated)</a>
11	<a href="#">BIC (vectors, unpredicated)</a>

## SVE Index Generation

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00000100									1							0100			op0												

Decode fields op0	Instruction details
00	<a href="#">INDEX (immediates)</a>
01	<a href="#">INDEX (scalar, immediate)</a>
10	<a href="#">INDEX (immediate, scalar)</a>
11	<a href="#">INDEX (scalars)</a>

## SVE Stack Allocation

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
00000100								op0			1							0101			op1											

Decode fields op0	Decode fields op1	Instruction details
0	0	<a href="#">SVE stack frame adjustment</a>
1	0	<a href="#">SVE stack frame size</a>
	1	UNALLOCATED

## SVE stack frame adjustment

These instructions are under [SVE Stack Allocation](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	op		1	Rn					0 1 0 1 0					imm6					Rd				

Decode fields op	Instruction Details
0	<a href="#">ADDVL</a>
1	<a href="#">ADDPL</a>

## SVE stack frame size

These instructions are under [SVE Stack Allocation](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	op		1	opc2					0 1 0 1 0					imm6					Rd				

Decode fields op	opc2	Instruction Details
0	0XXXX	UNALLOCATED
0	10XXX	UNALLOCATED
0	110XX	UNALLOCATED
0	1110x	UNALLOCATED
0	11110	UNALLOCATED
0	11111	<a href="#">RDVL</a>
1		UNALLOCATED

## SVE Bitwise Shift - Unpredicated

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00000100									1							100	op0														

Decode fields op0	Instruction details
0	<a href="#">SVE bitwise shift by wide elements (unpredicated)</a>
1	<a href="#">SVE bitwise shift by immediate (unpredicated)</a>

### SVE bitwise shift by wide elements (unpredicated)

These instructions are under [SVE Bitwise Shift - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1	Zm						1	0	0	0	opc	Zn						Zd				

Decode fields opc	Instruction Details
00	<a href="#">ASR (wide elements, unpredicated)</a>
01	<a href="#">LSR (wide elements, unpredicated)</a>
10	UNALLOCATED
11	<a href="#">LSL (wide elements, unpredicated)</a>

### SVE bitwise shift by immediate (unpredicated)

These instructions are under [SVE Bitwise Shift - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	tszh	1	tszl	imm3			1	0	0	1	opc	Zn						Zd						

Decode fields opc	Instruction Details
00	<a href="#">ASR (immediate, unpredicated)</a>
01	<a href="#">LSR (immediate, unpredicated)</a>
10	UNALLOCATED
11	<a href="#">LSL (immediate, unpredicated)</a>

## SVE address generation

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	opc	1	Zm						1	0	1	0	msz	Zn						Zd				

Decode fields	Instruction Details
<b>opc</b>	
00	<a href="#">ADR — Unpacked 32-bit signed offsets</a>
01	<a href="#">ADR — Unpacked 32-bit unsigned offsets</a>
1x	<a href="#">ADR — Packed offsets</a>

## SVE Integer Misc - Unpredicated

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00000100									1							1011	op0														

Decode fields	Instruction details
<b>op0</b>	
0x	<a href="#">SVE floating-point trig select coefficient</a>
10	<a href="#">SVE floating-point exponential accelerator</a>
11	<a href="#">SVE constructive prefix (unpredicated)</a>

## SVE floating-point trig select coefficient

These instructions are under [SVE Integer Misc - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1	Zm						1	0	1	1	0	op	Zn						Zd			

Decode fields	Instruction Details
<b>op</b>	
0	<a href="#">FTSSEL</a>
1	UNALLOCATED

## SVE floating-point exponential accelerator

These instructions are under [SVE Integer Misc - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1	opc						1	0	1	1	1	0	Zn						Zd			

Decode fields	Instruction Details
<b>opc</b>	
00000	<a href="#">FEXPA</a>
00001	UNALLOCATED
0001x	UNALLOCATED
001xx	UNALLOCATED
01xxx	UNALLOCATED
1xxxx	UNALLOCATED

## SVE constructive prefix (unpredicated)

These instructions are under [SVE Integer Misc - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	opc	1	opc2						1	0	1	1	1	1	Zn						Zd			

Decode fields		Instruction Details
opc	opc2	
00	00000	<a href="#">MOVPREX (unpredicated)</a>
00	00001	UNALLOCATED
00	0001x	UNALLOCATED
00	001xx	UNALLOCATED
00	01xxx	UNALLOCATED
00	1xxxx	UNALLOCATED
01		UNALLOCATED
1x		UNALLOCATED

## SVE Element Count

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00000100								1	op0					11	op1																

Decode fields		Instruction details
op0	op1	
0	00x	<a href="#">SVE saturating inc/dec vector by element count</a>
0	100	<a href="#">SVE element count</a>
0	101	UNALLOCATED
1	000	<a href="#">SVE inc/dec vector by element count</a>
1	100	<a href="#">SVE inc/dec register by element count</a>
1	x01	UNALLOCATED
	01x	UNALLOCATED
	11x	<a href="#">SVE saturating inc/dec register by element count</a>

## SVE saturating inc/dec vector by element count

These instructions are under [SVE Element Count](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size		1	0	imm4				1	1	0	0	D	U	pattern				Zdn					

Decode fields			Instruction Details
size	D	U	
00			UNALLOCATED
01	0	0	<a href="#">SQINCH (vector)</a>
01	0	1	<a href="#">UQINCH (vector)</a>
01	1	0	<a href="#">SQDECH (vector)</a>
01	1	1	<a href="#">UQDECH (vector)</a>
10	0	0	<a href="#">SQINCW (vector)</a>
10	0	1	<a href="#">UQINCW (vector)</a>
10	1	0	<a href="#">SQDECW (vector)</a>
10	1	1	<a href="#">UQDECW (vector)</a>
11	0	0	<a href="#">SQINCD (vector)</a>
11	0	1	<a href="#">UQINCD (vector)</a>
11	1	0	<a href="#">SQDECD (vector)</a>
11	1	1	<a href="#">UQDECD (vector)</a>

**SVE element count**

These instructions are under [SVE Element Count](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1	0		imm4		1	1	1	0	0	op		pattern										Rd

Decode fields size	op	Instruction Details
	1	UNALLOCATED
00	0	<a href="#">CNTB, CNTD, CNTH, CNTW</a> — <a href="#">CNTB</a>
01	0	<a href="#">CNTB, CNTD, CNTH, CNTW</a> — <a href="#">CNTH</a>
10	0	<a href="#">CNTB, CNTD, CNTH, CNTW</a> — <a href="#">CNTW</a>
11	0	<a href="#">CNTB, CNTD, CNTH, CNTW</a> — <a href="#">CNTD</a>

**SVE inc/dec vector by element count**

These instructions are under [SVE Element Count](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1	1		imm4		1	1	0	0	0	D		pattern									Zdn	

Decode fields size	D	Instruction Details
00		UNALLOCATED
01	0	<a href="#">INCD, INCH, INCW (vector)</a> — <a href="#">INCH</a>
01	1	<a href="#">DECD, DECH, DECW (vector)</a> — <a href="#">DECH</a>
10	0	<a href="#">INCD, INCH, INCW (vector)</a> — <a href="#">INCW</a>
10	1	<a href="#">DECD, DECH, DECW (vector)</a> — <a href="#">DECW</a>
11	0	<a href="#">INCD, INCH, INCW (vector)</a> — <a href="#">INCD</a>
11	1	<a href="#">DECD, DECH, DECW (vector)</a> — <a href="#">DECD</a>

**SVE inc/dec register by element count**

These instructions are under [SVE Element Count](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1	1		imm4		1	1	1	0	0	D		pattern										Rdn

Decode fields size	D	Instruction Details
00	0	<a href="#">INCB, INCD, INCH, INCW (scalar)</a> — <a href="#">INCB</a>
00	1	<a href="#">DECB, DECD, DECH, DECW (scalar)</a> — <a href="#">DECB</a>
01	0	<a href="#">INCB, INCD, INCH, INCW (scalar)</a> — <a href="#">INCH</a>
01	1	<a href="#">DECB, DECD, DECH, DECW (scalar)</a> — <a href="#">DECH</a>
10	0	<a href="#">INCB, INCD, INCH, INCW (scalar)</a> — <a href="#">INCW</a>
10	1	<a href="#">DECB, DECD, DECH, DECW (scalar)</a> — <a href="#">DECW</a>
11	0	<a href="#">INCB, INCD, INCH, INCW (scalar)</a> — <a href="#">INCD</a>
11	1	<a href="#">DECB, DECD, DECH, DECW (scalar)</a> — <a href="#">DECD</a>

**SVE saturating inc/dec register by element count**

These instructions are under [SVE Element Count](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1	sf		imm4		1	1	1	1	D	U		pattern										Rdn



Decode fields				Instruction Details
size	sf	D	U	
00	0	0	0	<a href="#">SQINCB — 32-bit</a>
00	0	0	1	<a href="#">UQINCB — 32-bit</a>
00	0	1	0	<a href="#">SQDECB — 32-bit</a>
00	0	1	1	<a href="#">UQDECB — 32-bit</a>
00	1	0	0	<a href="#">SQINCB — 64-bit</a>
00	1	0	1	<a href="#">UQINCB — 64-bit</a>
00	1	1	0	<a href="#">SQDECB — 64-bit</a>
00	1	1	1	<a href="#">UQDECB — 64-bit</a>
01	0	0	0	<a href="#">SQINCH (scalar) — 32-bit</a>
01	0	0	1	<a href="#">UQINCH (scalar) — 32-bit</a>
01	0	1	0	<a href="#">SQDECH (scalar) — 32-bit</a>
01	0	1	1	<a href="#">UQDECH (scalar) — 32-bit</a>
01	1	0	0	<a href="#">SQINCH (scalar) — 64-bit</a>
01	1	0	1	<a href="#">UQINCH (scalar) — 64-bit</a>
01	1	1	0	<a href="#">SQDECH (scalar) — 64-bit</a>
01	1	1	1	<a href="#">UQDECH (scalar) — 64-bit</a>
10	0	0	0	<a href="#">SQINCW (scalar) — 32-bit</a>
10	0	0	1	<a href="#">UQINCW (scalar) — 32-bit</a>
10	0	1	0	<a href="#">SQDECW (scalar) — 32-bit</a>
10	0	1	1	<a href="#">UQDECW (scalar) — 32-bit</a>
10	1	0	0	<a href="#">SQINCW (scalar) — 64-bit</a>
10	1	0	1	<a href="#">UQINCW (scalar) — 64-bit</a>
10	1	1	0	<a href="#">SQDECW (scalar) — 64-bit</a>
10	1	1	1	<a href="#">UQDECW (scalar) — 64-bit</a>
11	0	0	0	<a href="#">SQINCD (scalar) — 32-bit</a>
11	0	0	1	<a href="#">UQINCD (scalar) — 32-bit</a>
11	0	1	0	<a href="#">SQDECD (scalar) — 32-bit</a>
11	0	1	1	<a href="#">UQDECD (scalar) — 32-bit</a>
11	1	0	0	<a href="#">SQINCD (scalar) — 64-bit</a>
11	1	0	1	<a href="#">UQINCD (scalar) — 64-bit</a>
11	1	1	0	<a href="#">SQDECD (scalar) — 64-bit</a>
11	1	1	1	<a href="#">UQDECD (scalar) — 64-bit</a>

## SVE Bitwise Immediate

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00000101								op0		00		op1																			

Decode fields		Instruction details
op0	op1	
11	00	<a href="#">DUPM</a>
!= 11	00	<a href="#">SVE bitwise logical with immediate (unpredicated)</a>
	!= 00	UNALLOCATED

## SVE bitwise logical with immediate (unpredicated)

These instructions are under [SVE Bitwise Immediate](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	!= 11	0	0	0	0	imm13														Zdn				
opc																															

The following constraints also apply to this encoding: `opc != 11 && opc != 11`

Decode fields opc	Instruction Details
00	<a href="#">ORR (immediate)</a>
01	<a href="#">EOR (immediate)</a>
10	<a href="#">AND (immediate)</a>

## SVE Integer Wide Immediate - Predicated

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00000101										01						op0															

Decode fields op0	Instruction details
0xx	<a href="#">SVE copy integer immediate (predicated)</a>
10x	UNALLOCATED
110	<a href="#">FCPY</a>
111	UNALLOCATED

## SVE copy integer immediate (predicated)

These instructions are under [SVE Integer Wide Immediate - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	0	1	Pg			0	M	sh	imm8								Zd						

Decode fields M	Instruction Details
0	<a href="#">CPY (immediate, zeroing)</a>
1	<a href="#">CPY (immediate, merging)</a>

## SVE Permute Vector - Unpredicated

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00000101										1	op0	op1	001110																		

Decode fields op0	Decode fields op1	Instruction details
00	000	<a href="#">DUP (scalar)</a>
00	100	<a href="#">INSR (scalar)</a>
00	x10	UNALLOCATED
00	xx1	UNALLOCATED
01		UNALLOCATED
10	0xx	<a href="#">SVE unpack vector elements</a>
10	100	<a href="#">INSR (SIMD&amp;FP scalar)</a>
10	110	UNALLOCATED

10	1x1	UNALLOCATED
11	000	<a href="#">REV (vector)</a>
11	!= 000	UNALLOCATED

## SVE unpack vector elements

These instructions are under [SVE Permute Vector - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	1	0	0	U	H	0	0	1	1	1	0	Zn				Zd						

Decode fields		Instruction Details
U	H	
0	0	<a href="#">SUNPKHI, SUNPKLO</a> — <a href="#">SUNPKLO</a>
0	1	<a href="#">SUNPKHI, SUNPKLO</a> — <a href="#">SUNPKHI</a>
1	0	<a href="#">UUNPKHI, UUNPKLO</a> — <a href="#">UUNPKLO</a>
1	1	<a href="#">UUNPKHI, UUNPKLO</a> — <a href="#">UUNPKHI</a>

## SVE Permute Predicate

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00000101								op0		1	op1				010		op2								op3						

Decode fields				Instruction details
op0	op1	op2	op3	
00	1000x	0000	0	<a href="#">SVE unpack predicate elements</a>
01	1000x	0000	0	UNALLOCATED
10	1000x	0000	0	UNALLOCATED
11	1000x	0000	0	UNALLOCATED
	0xxxx	xxx0	0	<a href="#">SVE permute predicate elements</a>
	0xxxx	xxx1	0	UNALLOCATED
	10100	0000	0	<a href="#">REV (predicate)</a>
	10101	0000	0	UNALLOCATED
	10x0x	1000	0	UNALLOCATED
	10x0x	x100	0	UNALLOCATED
	10x0x	xx10	0	UNALLOCATED
	10x0x	xxx1	0	UNALLOCATED
	10x1x		0	UNALLOCATED
	11xxx		0	UNALLOCATED
			1	UNALLOCATED

## SVE unpack predicate elements

These instructions are under [SVE Permute Predicate](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	0	0	1	1	0	0	0	H	0	1	0	0	0	0	0		Pn				0	Pd		

Decode fields		Instruction Details
H		
0		<a href="#">PUNPKHI, PUNPKLO</a> — <a href="#">PUNPKLO</a>

**Decode fields**  
**H**
**Instruction Details**

1	<a href="#">PUNPKHI, PUNPKLO</a> — <a href="#">PUNPKHI</a>
---	--

**SVE permute predicate elements**

These instructions are under [SVE Permute Predicate](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0		Pm				0	1	0	opc	H	0		Pn			0			Pd		

**Decode fields**  
**opc**      **H**
**Instruction Details**

00	0	<a href="#">ZIP1, ZIP2 (predicates)</a> — <a href="#">ZIP1</a>
00	1	<a href="#">ZIP1, ZIP2 (predicates)</a> — <a href="#">ZIP2</a>
01	0	<a href="#">UZP1, UZP2 (predicates)</a> — <a href="#">UZP1</a>
01	1	<a href="#">UZP1, UZP2 (predicates)</a> — <a href="#">UZP2</a>
10	0	<a href="#">TRN1, TRN2 (predicates)</a> — <a href="#">TRN1</a>
10	1	<a href="#">TRN1, TRN2 (predicates)</a> — <a href="#">TRN2</a>
11		UNALLOCATED

**SVE permute vector elements**

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1			Zm				0	1	1	opc				Zn						Zd		

**Decode fields**  
**opc**
**Instruction Details**

000	<a href="#">ZIP1, ZIP2 (vectors)</a> — <a href="#">ZIP1</a>
001	<a href="#">ZIP1, ZIP2 (vectors)</a> — <a href="#">ZIP2</a>
010	<a href="#">UZP1, UZP2 (vectors)</a> — <a href="#">UZP1</a>
011	<a href="#">UZP1, UZP2 (vectors)</a> — <a href="#">UZP2</a>
100	<a href="#">TRN1, TRN2 (vectors)</a> — <a href="#">TRN1</a>
101	<a href="#">TRN1, TRN2 (vectors)</a> — <a href="#">TRN2</a>
11x	UNALLOCATED

**SVE Permute Vector - Predicated**

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
										1	op0	op1	op2	10	op3																

Decode fields				Instruction details
op0	op1	op2	op3	
0	000	0	0	<a href="#">CPY (SIMD&amp;FP scalar)</a>
0	000	1	0	<a href="#">COMPACT</a>
0	000		1	<a href="#">SVE extract element to general register</a>
0	001		0	<a href="#">SVE extract element to SIMD&amp;FP scalar register</a>
0	01x		0	<a href="#">SVE reverse within elements</a>
0	01x		1	UNALLOCATED
0	100	0	1	<a href="#">CPY (scalar)</a>

0	100	1	1	UNALLOCATED
0	100		0	<a href="#">SVE conditionally broadcast element to vector</a>
0	101		0	<a href="#">SVE conditionally extract element to SIMD&amp;FP scalar</a>
0	110	0	0	<a href="#">SPLICE</a>
0	110	0	1	UNALLOCATED
0	110	1		UNALLOCATED
0	111	0	0	UNALLOCATED
0	111	0	1	UNALLOCATED
0	111	1		UNALLOCATED
0	x01		1	UNALLOCATED
1	000		0	UNALLOCATED
1	000		1	<a href="#">SVE conditionally extract element to general register</a>
1	!= 000			UNALLOCATED

## SVE extract element to general register

These instructions are under [SVE Permute Vector - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	0	0	0	B	1	0	1	Pg													

Decode fields	Instruction Details
<b>B</b>	
0	<a href="#">LASTA (scalar)</a>
1	<a href="#">LASTB (scalar)</a>

## SVE extract element to SIMD&FP scalar register

These instructions are under [SVE Permute Vector - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	0	0	1	B	1	0	0	Pg													

Decode fields	Instruction Details
<b>B</b>	
0	<a href="#">LASTA (SIMD&amp;FP scalar)</a>
1	<a href="#">LASTB (SIMD&amp;FP scalar)</a>

## SVE reverse within elements

These instructions are under [SVE Permute Vector - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	0	1	opc	1	0	0	Pg														

Decode fields	Instruction Details
<b>opc</b>	
00	<a href="#">REVB, REVH, REVW</a> — <a href="#">REVB</a>
01	<a href="#">REVB, REVH, REVW</a> — <a href="#">REVH</a>
10	<a href="#">REVB, REVH, REVW</a> — <a href="#">RE VW</a>
11	<a href="#">RBIT</a>

**SVE conditionally broadcast element to vector**

These instructions are under [SVE Permute Vector - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	1	0	0	B	1	0	0	Pg					Zm							Zdn	

Decode fields B	Instruction Details
0	<a href="#">CLASTA (vectors)</a>
1	<a href="#">CLASTB (vectors)</a>

**SVE conditionally extract element to SIMD&FP scalar**

These instructions are under [SVE Permute Vector - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	1	0	1	B	1	0	0	Pg					Zm							Vdn	

Decode fields B	Instruction Details
0	<a href="#">CLASTA (SIMD&amp;FP scalar)</a>
1	<a href="#">CLASTB (SIMD&amp;FP scalar)</a>

**SVE conditionally extract element to general register**

These instructions are under [SVE Permute Vector - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	1	0	0	0	B	1	0	1	Pg					Zm							Rdn	

Decode fields B	Instruction Details
0	<a href="#">CLASTA (scalar)</a>
1	<a href="#">CLASTB (scalar)</a>

**SVE Permute Vector - Extract**

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
									000001010	op0	1								000												

Decode fields op0	Instruction details
0	<a href="#">EXT</a>
1	UNALLOCATED

**SVE permute vector segments**

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	1	op	1					Zm				0	0	0	opc2				Zn				Zd	

Decode fields op	Decode fields opc2	Instruction Details
0	000	<a href="#">ZIP1, ZIP2 (vectors)</a> — <a href="#">ZIP1</a>

Decode fields		Instruction Details
op	opc2	
0	001	<a href="#">ZIP1, ZIP2 (vectors) — ZIP2</a>
0	010	<a href="#">UZP1, UZP2 (vectors) — UZP1</a>
0	011	<a href="#">UZP1, UZP2 (vectors) — UZP2</a>
0	10x	UNALLOCATED
0	110	<a href="#">TRN1, TRN2 (vectors) — TRN1</a>
0	111	<a href="#">TRN1, TRN2 (vectors) — TRN2</a>
1		UNALLOCATED

## SVE Integer Compare - Vectors

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00100100										0							op0														

Decode fields		Instruction details
op0		
0		<a href="#">SVE integer compare vectors</a>
1		<a href="#">SVE integer compare with wide elements</a>

## SVE integer compare vectors

These instructions are under [SVE Integer Compare - Vectors](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size		0		Zm				op	0	o2		Pg				Zn		ne			Pd		

Decode fields			Instruction Details
op	o2	ne	
0	0	0	<a href="#">CMP&lt;cc&gt; (vectors) — CMPHS</a>
0	0	1	<a href="#">CMP&lt;cc&gt; (vectors) — CMPHI</a>
0	1	0	<a href="#">CMP&lt;cc&gt; (wide elements) — CMPEQ</a>
0	1	1	<a href="#">CMP&lt;cc&gt; (wide elements) — CMPNE</a>
1	0	0	<a href="#">CMP&lt;cc&gt; (vectors) — CMPGE</a>
1	0	1	<a href="#">CMP&lt;cc&gt; (vectors) — CMPGT</a>
1	1	0	<a href="#">CMP&lt;cc&gt; (vectors) — CMPEQ</a>
1	1	1	<a href="#">CMP&lt;cc&gt; (vectors) — CMPNE</a>

## SVE integer compare with wide elements

These instructions are under [SVE Integer Compare - Vectors](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size		0		Zm				U	1	lt		Pg				Zn		ne			Pd		

Decode fields			Instruction Details
U	lt	ne	
0	0	0	<a href="#">CMP&lt;cc&gt; (wide elements) — CMPGE</a>
0	0	1	<a href="#">CMP&lt;cc&gt; (wide elements) — CMPGT</a>
0	1	0	<a href="#">CMP&lt;cc&gt; (wide elements) — CMPLT</a>
0	1	1	<a href="#">CMP&lt;cc&gt; (wide elements) — CMPLE</a>
1	0	0	<a href="#">CMP&lt;cc&gt; (wide elements) — CMPHS</a>

Decode fields			Instruction Details
U	lt	ne	
1	0	1	<a href="#">CMP&lt;cc&gt; (wide elements) — CMPHI</a>
1	1	0	<a href="#">CMP&lt;cc&gt; (wide elements) — CMPLO</a>
1	1	1	<a href="#">CMP&lt;cc&gt; (wide elements) — CMPLS</a>

## SVE integer compare with unsigned immediate

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size	1	imm7						lt	Pg		Zn				ne	Pd							

Decode fields		Instruction Details
lt	ne	
0	0	<a href="#">CMP&lt;cc&gt; (immediate) — CMPHS</a>
0	1	<a href="#">CMP&lt;cc&gt; (immediate) — CMPHI</a>
1	0	<a href="#">CMP&lt;cc&gt; (immediate) — CMPLO</a>
1	1	<a href="#">CMP&lt;cc&gt; (immediate) — CMPLS</a>

## SVE integer compare with signed immediate

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	0	imm5			op	0	o2	Pg		Zn				ne		Pd							

Decode fields			Instruction Details
op	o2	ne	
0	0	0	<a href="#">CMP&lt;cc&gt; (immediate) — CMPGE</a>
0	0	1	<a href="#">CMP&lt;cc&gt; (immediate) — CMPGT</a>
0	1	0	<a href="#">CMP&lt;cc&gt; (immediate) — CMPLT</a>
0	1	1	<a href="#">CMP&lt;cc&gt; (immediate) — CMPLE</a>
1	0	0	<a href="#">CMP&lt;cc&gt; (immediate) — CMPEQ</a>
1	0	1	<a href="#">CMP&lt;cc&gt; (immediate) — CMPNE</a>
1	1		UNALLOCATED

## SVE predicate logical operations

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	op	S	0	0	Pm			0		1	Pg			o2		Pn			o3		Pd			

Decode fields				Instruction Details
op	S	o2	o3	
0	0	0	0	<a href="#">AND, ANDS (predicates) — not setting the condition flags</a>
0	0	0	1	<a href="#">BIC, BICS (predicates) — not setting the condition flags</a>
0	0	1	0	<a href="#">EOR, EORS (predicates) — not setting the condition flags</a>
0	0	1	1	<a href="#">SEL (predicates)</a>
0	1	0	0	<a href="#">AND, ANDS (predicates) — setting the condition flags</a>
0	1	0	1	<a href="#">BIC, BICS (predicates) — setting the condition flags</a>
0	1	1	0	<a href="#">EOR, EORS (predicates) — setting the condition flags</a>
0	1	1	1	UNALLOCATED



Decode fields				Instruction Details
op	S	o2	o3	
1	0	0	0	<a href="#">ORR, ORRS (predicates) — not setting the condition flags</a>
1	0	0	1	<a href="#">ORN, ORNS (predicates) — not setting the condition flags</a>
1	0	1	0	<a href="#">NOR, NORS — not setting the condition flags</a>
1	0	1	1	<a href="#">NAND, NANDS — not setting the condition flags</a>
1	1	0	0	<a href="#">ORR, ORRS (predicates) — setting the condition flags</a>
1	1	0	1	<a href="#">ORN, ORNS (predicates) — setting the condition flags</a>
1	1	1	0	<a href="#">NOR, NORS — setting the condition flags</a>
1	1	1	1	<a href="#">NAND, NANDS — setting the condition flags</a>

## SVE Propagate Break

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00100101										00						11						op0									

Decode fields		Instruction details
op0		
0		<a href="#">SVE propagate break from previous partition</a>
1		UNALLOCATED

## SVE propagate break from previous partition

These instructions are under [SVE Propagate Break](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	op	S	0	0	Pm		1	1	Pg		0	Pn		B	Pd									

Decode fields			Instruction Details
op	S	B	
0	0	0	<a href="#">BRKPA, BRKPAS — not setting the condition flags</a>
0	0	1	<a href="#">BRKPB, BRKPBS — not setting the condition flags</a>
0	1	0	<a href="#">BRKPA, BRKPAS — setting the condition flags</a>
0	1	1	<a href="#">BRKPB, BRKPBS — setting the condition flags</a>
1			UNALLOCATED

## SVE Partition Break

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00100101								op0		01	op1		01					op2					op3								

Decode fields				Instruction details
op0	op1	op2	op3	
0	1000	0	0	<a href="#">SVE propagate break to next partition</a>
0	1000	0	1	UNALLOCATED
0	x000	1		UNALLOCATED
0	x1xx			UNALLOCATED
0	xx1x			UNALLOCATED
0	xxx1			UNALLOCATED

1	0000	1		UNALLOCATED
1	!= 0000			UNALLOCATED
	0000	0		<a href="#">SVE partition break condition</a>

### SVE propagate break to next partition

These instructions are under [SVE Partition Break](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	S	0	1	1	0	0	0	0	1		Pg		0		Pn		0		Pdm				

#### Decode fields

S

#### Instruction Details

0	<a href="#">BRKN, BRKNS</a> — <a href="#">not setting the condition flags</a>
1	<a href="#">BRKN, BRKNS</a> — <a href="#">setting the condition flags</a>

### SVE partition break condition

These instructions are under [SVE Partition Break](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	B	S	0	1	0	0	0	0	0	1		Pg		0		Pn		M		Pd				

#### Decode fields

B

S

M

#### Instruction Details

	1	1	UNALLOCATED
0	0		<a href="#">BRKA, BRKAS</a> — <a href="#">not setting the condition flags</a>
0	1	0	<a href="#">BRKA, BRKAS</a> — <a href="#">setting the condition flags</a>
1	0		<a href="#">BRKB, BRKBS</a> — <a href="#">not setting the condition flags</a>
1	1	0	<a href="#">BRKB, BRKBS</a> — <a href="#">setting the condition flags</a>

### SVE Predicate Misc

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
										01			op0			11		op1		op2				op3		op4					

#### Decode fields

op0

op1

op2

op3

op4

#### Instruction details

0000		x0		0	<a href="#">SVE predicate test</a>
0100		x0		0	UNALLOCATED
0x10		x0		0	UNALLOCATED
0xx1		x0		0	UNALLOCATED
0xxx		x1		0	UNALLOCATED
1000	000	00		0	<a href="#">SVE predicate first active</a>
1000	000	!= 00		0	UNALLOCATED
1000	100	10	0000	0	<a href="#">SVE predicate zero</a>
1000	100	10	!= 0000	0	UNALLOCATED
1000	110	00		0	<a href="#">SVE predicate read from FFR (predicated)</a>
1001	000	0x		0	UNALLOCATED
1001	000	10		0	<a href="#">PNEXT</a>
1001	000	11		0	UNALLOCATED

1001	100	10		0	UNALLOCATED
1001	110	00	0000	0	<a href="#">SVE predicate read from FFR (unpredicated)</a>
1001	110	00	!= 0000	0	UNALLOCATED
100x	010			0	UNALLOCATED
100x	100	0x		0	<a href="#">SVE predicate initialize</a>
100x	100	11		0	UNALLOCATED
100x	110	!= 00		0	UNALLOCATED
100x	xx1			0	UNALLOCATED
110x				0	UNALLOCATED
1x1x				0	UNALLOCATED
				1	UNALLOCATED

## SVE predicate test

These instructions are under [SVE Predicate Misc.](#)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	op	S	0	1	0	0	0	0	1	1		Pg		0		Pn		0		opc2				

Decode fields			Instruction Details
op	S	opc2	
0	0		UNALLOCATED
0	1	0000	<a href="#">PTEST</a>
0	1	0001	UNALLOCATED
0	1	001x	UNALLOCATED
0	1	01xx	UNALLOCATED
0	1	1xxx	UNALLOCATED
1			UNALLOCATED

## SVE predicate first active

These instructions are under [SVE Predicate Misc.](#)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	op	S	0	1	1	0	0	0	1	1	0	0	0	0	0	0		Pg		0		Pdn		

Decode fields		Instruction Details
op	S	
0	0	UNALLOCATED
0	1	<a href="#">PFIRST</a>
1		UNALLOCATED

## SVE predicate zero

These instructions are under [SVE Predicate Misc.](#)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	op	S	0	1	1	0	0	0	1	1	1	0	0	1	0	0	0	0	0	0			Pd	

Decode fields		Instruction Details
op	S	
0	0	<a href="#">PFALSE</a>
0	1	UNALLOCATED

Decode fields	Instruction Details	
op	S	
1		UNALLOCATED

### SVE predicate read from FFR (predicated)

These instructions are under [SVE Predicate Misc](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	op	S	0	1	1	0	0	0	1	1	1	1	0	0	0		Pg		0			Pd		

Decode fields	Instruction Details	
op	S	
0	0	<a href="#">RDFFR, RDFFRS (predicated)</a> — <a href="#">not setting the condition flags</a>
0	1	<a href="#">RDFFR, RDFFRS (predicated)</a> — <a href="#">setting the condition flags</a>
1		UNALLOCATED

### SVE predicate read from FFR (unpredicated)

These instructions are under [SVE Predicate Misc](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	op	S	0	1	1	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	Pd			

Decode fields	Instruction Details	
op	S	
0	0	<a href="#">RDFFR (unpredicated)</a>
0	1	UNALLOCATED
1		UNALLOCATED

### SVE predicate initialize

These instructions are under [SVE Predicate Misc](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size		0	1	1	0	0	S	1	1	1	0	0	0		pattern		0			Pd			

Decode fields	Instruction Details	
S		
0		<a href="#">PTRUE, PTRUES</a> — <a href="#">not setting the condition flags</a>
1		<a href="#">PTRUE, PTRUES</a> — <a href="#">setting the condition flags</a>

### SVE Integer Compare - Scalars

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
										1						00	op0	op1												op2	

Decode fields	Instruction details		
op0	op1	op2	
0			<a href="#">SVE integer compare scalar count and limit</a>
1	000	0000	<a href="#">SVE conditionally terminate scalars</a>
1	000	!= 0000	UNALLOCATED
1	!= 000		UNALLOCATED

**SVE integer compare scalar count and limit**

These instructions are under [SVE Integer Compare - Scalars](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	Rm			0	0	0	sf	U	lt	Rn			eq	Pd								

Decode fields			Instruction Details
U	lt	eq	
	0		UNALLOCATED
0	1	0	<a href="#">WHILELT</a>
0	1	1	<a href="#">WHILELE</a>
1	1	0	<a href="#">WHILELO</a>
1	1	1	<a href="#">WHILELS</a>

**SVE conditionally terminate scalars**

These instructions are under [SVE Integer Compare - Scalars](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	op	sz	1			Rm			0	0	1	0	0	0				Rn		ne	0	0	0	0

Decode fields		Instruction Details
op	ne	
0		UNALLOCATED
1	0	<a href="#">CTERMEQ, CTERMNE</a> — <a href="#">CTERMEQ</a>
1	1	<a href="#">CTERMEQ, CTERMNE</a> — <a href="#">CTERMNE</a>

**SVE Integer Wide Immediate - Unpredicated**

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
										1	op0				op1	11															

Decode fields		Instruction details
op0	op1	
00		<a href="#">SVE integer add/subtract immediate (unpredicated)</a>
01		<a href="#">SVE integer min/max immediate (unpredicated)</a>
10		<a href="#">SVE integer multiply immediate (unpredicated)</a>
11	0	<a href="#">SVE broadcast integer immediate (unpredicated)</a>
11	1	<a href="#">SVE broadcast floating-point immediate (unpredicated)</a>

**SVE integer add/subtract immediate (unpredicated)**

These instructions are under [SVE Integer Wide Immediate - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	0	0		opc		1	1	sh														Zdn

Decode fields		Instruction Details
opc		
000		<a href="#">ADD (immediate)</a>
001		<a href="#">SUB (immediate)</a>
010		UNALLOCATED
011		<a href="#">SUBR (immediate)</a>

Decode fields opc	Instruction Details
100	<a href="#">SQADD (immediate)</a>
101	<a href="#">UQADD (immediate)</a>
110	<a href="#">SQSUB (immediate)</a>
111	<a href="#">UQSUB (immediate)</a>

**SVE integer min/max immediate (unpredicated)**

These instructions are under [SVE Integer Wide Immediate - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	0	1	opc		1	1	o2	imm8								Zdn						

Decode fields opc	o2	Instruction Details
0xx	1	UNALLOCATED
000	0	<a href="#">SMAX (immediate)</a>
001	0	<a href="#">UMAX (immediate)</a>
010	0	<a href="#">SMIN (immediate)</a>
011	0	<a href="#">UMIN (immediate)</a>
1xx		UNALLOCATED

**SVE integer multiply immediate (unpredicated)**

These instructions are under [SVE Integer Wide Immediate - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size		1	1	0	opc		1		1	o2	imm8								Zdn				

Decode fields opc	o2	Instruction Details
000	0	<a href="#">MUL (immediate)</a>
000	1	UNALLOCATED
001		UNALLOCATED
01x		UNALLOCATED
1xx		UNALLOCATED

**SVE broadcast integer immediate (unpredicated)**

These instructions are under [SVE Integer Wide Immediate - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	0	1	0	0	1	0	1	size		1	1	1	opc		0	1	1	sh	imm8										Zd				

Decode fields opc	Instruction Details
00	<a href="#">DUP (immediate)</a>
01	UNALLOCATED
1x	UNALLOCATED

**SVE broadcast floating-point immediate (unpredicated)**

These instructions are under [SVE Integer Wide Immediate - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size		1	1	1	opc		1	1	1	o2	imm8								Zd				

Decode fields		Instruction Details
opc	o2	
00	0	<a href="#">FDUP</a>
00	1	UNALLOCATED
01		UNALLOCATED
1x		UNALLOCATED

## SVE Predicate Count

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00100101										100				10						op0											

Decode fields		Instruction details
op0		
0		<a href="#">SVE predicate count</a>
1		UNALLOCATED

## SVE predicate count

These instructions are under [SVE Predicate Count](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size		1	0	0	opc		1	0	Pg		0	Pn		Rd									

Decode fields		Instruction Details
opc		
000		<a href="#">CNTp</a>
001		UNALLOCATED
01x		UNALLOCATED
1xx		UNALLOCATED

## SVE Inc/Dec by Predicate Count

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00100101									101		op0		1000		op1																

Decode fields		Instruction details
op0	op1	
0	0	<a href="#">SVE saturating inc/dec vector by predicate count</a>
0	1	<a href="#">SVE saturating inc/dec register by predicate count</a>
1	0	<a href="#">SVE inc/dec vector by predicate count</a>
1	1	<a href="#">SVE inc/dec register by predicate count</a>

## SVE saturating inc/dec vector by predicate count

These instructions are under [SVE Inc/Dec by Predicate Count](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size		1	0	1	0	D	U	1	0	0	0	0	opc		Pm				Zdn				

Decode fields			Instruction Details
D	U	opc	
		01	UNALLOCATED
		1x	UNALLOCATED
0	0	00	<a href="#">SQINCP (vector)</a>
0	1	00	<a href="#">UQINCP (vector)</a>
1	0	00	<a href="#">SQDECP (vector)</a>
1	1	00	<a href="#">UQDECP (vector)</a>

### SVE saturating inc/dec register by predicate count

These instructions are under [SVE Inc/Dec by Predicate Count](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	0	1	0	D	U	1	0	0	0	1	sf	op	Pm			Rdn						

Decode fields				Instruction Details
D	U	sf	op	
			1	UNALLOCATED
0	0	0	0	<a href="#">SQINCP (scalar) — 32-bit</a>
0	0	1	0	<a href="#">SQINCP (scalar) — 64-bit</a>
0	1	0	0	<a href="#">UQINCP (scalar) — 32-bit</a>
0	1	1	0	<a href="#">UQINCP (scalar) — 64-bit</a>
1	0	0	0	<a href="#">SQDECP (scalar) — 32-bit</a>
1	0	1	0	<a href="#">SQDECP (scalar) — 64-bit</a>
1	1	0	0	<a href="#">UQDECP (scalar) — 32-bit</a>
1	1	1	0	<a href="#">UQDECP (scalar) — 64-bit</a>

### SVE inc/dec vector by predicate count

These instructions are under [SVE Inc/Dec by Predicate Count](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	0	1	1	op	D	1	0	0	0	0	opc2	Pm			Zdn							

Decode fields			Instruction Details
op	D	opc2	
0		01	UNALLOCATED
0		1x	UNALLOCATED
0	0	00	<a href="#">INCP (vector)</a>
0	1	00	<a href="#">DECP (vector)</a>
1			UNALLOCATED

### SVE inc/dec register by predicate count

These instructions are under [SVE Inc/Dec by Predicate Count](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	0	1	1	op	D	1	0	0	0	1	opc2	Pm			Rdn							

Decode fields			Instruction Details
op	D	opc2	
0		01	UNALLOCATED
0		1x	UNALLOCATED



Decode fields			Instruction Details
op	D	opc2	
0	0	00	<a href="#">INCP (scalar)</a>
0	1	00	<a href="#">DECP (scalar)</a>
1			UNALLOCATED

## SVE Write FFR

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00100101										101		op0	op1			1001				op2				op3					op4		

Decode fields					Instruction details
op0	op1	op2	op3	op4	
0	00	000		00000	<a href="#">SVE FFR write from predicate</a>
1	00	000	0000	00000	<a href="#">SVE FFR initialise</a>
1	00	000	1xxx	00000	UNALLOCATED
1	00	000	x1xx	00000	UNALLOCATED
1	00	000	xx1x	00000	UNALLOCATED
1	00	000	xxx1	00000	UNALLOCATED
	00	000		!= 00000	UNALLOCATED
	00	!= 000			UNALLOCATED
	!= 00				UNALLOCATED

## SVE FFR write from predicate

These instructions are under [SVE Write FFR](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	opc	1	0	1	0	0	0	1	0	0	1	0	0	0	0		Pn		0	0	0	0	0	0

Decode fields	Instruction Details
opc	
00	<a href="#">WRFFR</a>
01	UNALLOCATED
1x	UNALLOCATED

## SVE FFR initialise

These instructions are under [SVE Write FFR](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	opc	1	0	1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

Decode fields	Instruction Details
opc	
00	<a href="#">SETFFR</a>
01	UNALLOCATED
1x	UNALLOCATED

## SVE Integer Multiply-Add - Unpredicated

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
01000100									0					0	op0	op1		op2													

Decode fields			Instruction details
op0	op1	op2	
0	000		<a href="#">SVE integer dot product (unpredicated)</a>
0	!= 000		UNALLOCATED
1	0xx		UNALLOCATED
1	10x		UNALLOCATED
1	110		UNALLOCATED
1	111	0	<a href="#">SVE mixed sign dot product</a>
1	111	1	UNALLOCATED

### SVE integer dot product (unpredicated)

These instructions are under [SVE Integer Multiply-Add - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	1	0	0	0	1	0	0	size	0	Zm						0	0	0	0	0	U	Zn						Zda				

Decode fields	Instruction Details
U	
0	<a href="#">SDOT (vectors)</a>
1	<a href="#">UDOT (vectors)</a>

### SVE mixed sign dot product

These instructions are under [SVE Integer Multiply-Add - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size	0	Zm						0	1	1	1	1	0	Zn						Zda			

Decode fields	Instruction Details
size	
0x	UNALLOCATED
10	<a href="#">USDOT (vectors)</a>
11	UNALLOCATED

### SVE Multiply - Indexed

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
01000100										1					op0		op1														

Decode fields		Instruction details
op0	op1	
000	00	<a href="#">SVE integer dot product (indexed)</a>
000	01	UNALLOCATED
000	10	UNALLOCATED
000	11	<a href="#">SVE mixed sign dot product (indexed)</a>
!= 000		UNALLOCATED

### SVE integer dot product (indexed)

These instructions are under [SVE Multiply - Indexed](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size	1			opc				0	0	0	0	0	U			Zn					Zda		

Decode fields size	U	Instruction Details
0x		UNALLOCATED
10	0	<a href="#">SDOT (indexed) — 32-bit</a>
10	1	<a href="#">UDOT (indexed) — 32-bit</a>
11	0	<a href="#">SDOT (indexed) — 64-bit</a>
11	1	<a href="#">UDOT (indexed) — 64-bit</a>

## SVE mixed sign dot product (indexed)

These instructions are under [SVE Multiply - Indexed](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size	1			opc				0	0	0	1	1	U			Zn					Zda		

Decode fields size	U	Instruction Details
0x		UNALLOCATED
10	0	<a href="#">USDOT (indexed)</a>
10	1	<a href="#">SUDOT</a>
11		UNALLOCATED

## SVE Misc

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Decode fields op0	Instruction details
00xx	UNALLOCATED
010x	UNALLOCATED
0110	<a href="#">SVE integer matrix multiply accumulate</a>
0111	UNALLOCATED
1xxx	UNALLOCATED

## SVE integer matrix multiply accumulate

These instructions are under [SVE Misc](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	uns	0			Zm				1	0	0	1	1	0			Zn					Zd		

Decode fields uns	Instruction Details
00	<a href="#">SMMLA</a>
01	UNALLOCATED
10	<a href="#">USMMLA</a>
11	<a href="#">UMMLA</a>

**SVE floating-point convert precision odd elements**

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	opc	0	0	1	0	opc2	1	0	1	Pg				Zn				Zd						

Decode fields		Instruction Details
opc	opc2	
0x		UNALLOCATED
10	0x	UNALLOCATED
10	10	<a href="#">BFCVTNT</a>
10	11	UNALLOCATED
11		UNALLOCATED

**SVE floating-point multiply-add (indexed)**

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	1	1	0	0	1	0	0	size	1	opc				0	0	0	0	0	0	op	Zn				Zda							

Decode fields		Instruction Details
size	op	
0x	0	<a href="#">FMLA (indexed)</a> — <a href="#">half-precision</a>
0x	1	<a href="#">FMLS (indexed)</a> — <a href="#">half-precision</a>
10	0	<a href="#">FMLA (indexed)</a> — <a href="#">single-precision</a>
10	1	<a href="#">FMLS (indexed)</a> — <a href="#">single-precision</a>
11	0	<a href="#">FMLA (indexed)</a> — <a href="#">double-precision</a>
11	1	<a href="#">FMLS (indexed)</a> — <a href="#">double-precision</a>

**SVE floating-point complex multiply-add (indexed)**

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	size	1	opc				0	0	0	1	rot				Zn				Zda					

Decode fields		Instruction Details
size		
0x		UNALLOCATED
10		<a href="#">FCMLA (indexed)</a> — <a href="#">half-precision</a>
11		<a href="#">FCMLA (indexed)</a> — <a href="#">single-precision</a>

**SVE floating-point multiply (indexed)**

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0			
0	1	1	0	0	1	0	0	size	1	opc				0	0	1	0	0	0	Zn				Zd										

Decode fields		Instruction Details
size		
0x		<a href="#">FMUL (indexed)</a> — <a href="#">half-precision</a>
10		<a href="#">FMUL (indexed)</a> — <a href="#">single-precision</a>
11		<a href="#">FMUL (indexed)</a> — <a href="#">double-precision</a>

## SVE Floating Point Widening Multiply-Add - Indexed

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
01100100								op0		1					01	op1	0	op2													

Decode fields			Instruction details
op0	op1	op2	
0	0	00	<a href="#">SVE BFloat16 floating-point dot product (indexed)</a>
0	0	!= 00	UNALLOCATED
0	1		UNALLOCATED
1			<a href="#">SVE floating-point multiply-add long (indexed)</a>

### SVE BFloat16 floating-point dot product (indexed)

These instructions are under [SVE Floating Point Widening Multiply-Add - Indexed](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	0	op	1	i2	Zm				0	1	0	0	0	0	Zn				Zda					

Decode fields		Instruction Details
op		
0		UNALLOCATED
1		<a href="#">BFDOT (indexed)</a>

### SVE floating-point multiply-add long (indexed)

These instructions are under [SVE Floating Point Widening Multiply-Add - Indexed](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	1	o2	1	i3h	Zm				0	1	op	0	i3l	T	Zn				Zda					

Decode fields			Instruction Details
o2	op	T	
0			UNALLOCATED
1	0	0	<a href="#">BFMLALB (indexed)</a>
1	0	1	<a href="#">BFMLALT (indexed)</a>
1	1		UNALLOCATED

## SVE Floating Point Widening Multiply-Add

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
01100100								op0		1					10	op1	00	op2													

Decode fields			Instruction details
op0	op1	op2	
0	0	0	<a href="#">SVE BFloat16 floating-point dot product</a>
0	0	1	UNALLOCATED
0	1		UNALLOCATED
1			<a href="#">SVE floating-point multiply-add long</a>

**SVE BFloat16 floating-point dot product**

These instructions are under [SVE Floating Point Widening Multiply-Add](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	0	op	1	Zm					1	0	0	0	0	0	Zn					Zda				

Decode fields op	Instruction Details
0	UNALLOCATED
1	<a href="#">BFDOT (vectors)</a>

**SVE floating-point multiply-add long**

These instructions are under [SVE Floating Point Widening Multiply-Add](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	1	o2	1	Zm					1	0	op	0	0	T	Zn					Zda				

Decode fields o2 op T	Instruction Details
0	UNALLOCATED
1 0 0	<a href="#">BFMLALB (vectors)</a>
1 0 1	<a href="#">BFMLALT (vectors)</a>
1 1	UNALLOCATED

**SVE floating point matrix multiply accumulate**

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	1	1	0	0	1	0	0	opc	1	Zm						1	1	1	0	0	1	Zn						Zda				

Decode fields opc	Instruction Details
00	UNALLOCATED
01	<a href="#">BFMMLA</a>
10	<a href="#">FMMLA</a> — <a href="#">32-bit element</a>
11	<a href="#">FMMLA</a> — <a href="#">64-bit element</a>

**SVE floating-point compare vectors**

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	Zm			op		1	o2	Pg			Zn				o3		Pd					

Decode fields op o2 o3	Instruction Details
0 0 0	<a href="#">FCM&lt;cc&gt; (vectors)</a> — <a href="#">FCMGE</a>
0 0 1	<a href="#">FCM&lt;cc&gt; (vectors)</a> — <a href="#">FCMGT</a>
0 1 0	<a href="#">FCM&lt;cc&gt; (vectors)</a> — <a href="#">FCMEQ</a>
0 1 1	<a href="#">FCM&lt;cc&gt; (vectors)</a> — <a href="#">FCMNE</a>
1 0 0	<a href="#">FCM&lt;cc&gt; (vectors)</a> — <a href="#">FCMUO</a>
1 0 1	<a href="#">FAC&lt;cc&gt;</a> — <a href="#">FACGE</a>
1 1 0	UNALLOCATED

Decode fields			Instruction Details
op	o2	o3	
1	1	1	<a href="#">FAC&lt;cc&gt; – FACGT</a>

## SVE floating-point arithmetic (unpredicated)

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0			Zm				0	0	0	opc					Zn					Zd		

Decode fields		Instruction Details
opc		
000		<a href="#">FADD (vectors, unpredicated)</a>
001		<a href="#">FSUB (vectors, unpredicated)</a>
010		<a href="#">FMUL (vectors, unpredicated)</a>
011		<a href="#">FTSMUL</a>
10x		UNALLOCATED
110		<a href="#">FRECPS</a>
111		<a href="#">FRSORTS</a>

## SVE Floating Point Arithmetic - Predicated

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
			0	1	1	0	0	1		0	op0					100			op1				op2								

Decode fields			Instruction details
op0	op1	op2	
0x			<a href="#">SVE floating-point arithmetic (predicated)</a>
10	000		<a href="#">FTMAD</a>
10	!= 000		UNALLOCATED
11		0000	<a href="#">SVE floating-point arithmetic with immediate (predicated)</a>
11		!= 0000	UNALLOCATED

## SVE floating-point arithmetic (predicated)

These instructions are under [SVE Floating Point Arithmetic - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	opc			1			0	0	Pg			Zm			Zdn						

Decode fields		Instruction Details
opc		
0000		<a href="#">FADD (vectors, predicated)</a>
0001		<a href="#">FSUB (vectors, predicated)</a>
0010		<a href="#">FMUL (vectors, predicated)</a>
0011		<a href="#">FSUBR (vectors)</a>
0100		<a href="#">FMAXNM (vectors)</a>
0101		<a href="#">FMINNM (vectors)</a>
0110		<a href="#">FMAX (vectors)</a>
0111		<a href="#">FMIN (vectors)</a>
1000		<a href="#">FABD</a>

Decode fields opc	Instruction Details
1001	<a href="#">FSCALE</a>
1010	<a href="#">FMULX</a>
1011	UNALLOCATED
1100	<a href="#">FDIVR</a>
1101	<a href="#">FDIV</a>
111x	UNALLOCATED

## SVE floating-point arithmetic with immediate (predicated)

These instructions are under [SVE Floating Point Arithmetic - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	1	1	opc	1	0	0	Pg	0	0	0	0	il	Zdn									

Decode fields opc	Instruction Details
000	<a href="#">FADD (immediate)</a>
001	<a href="#">FSUB (immediate)</a>
010	<a href="#">FMUL (immediate)</a>
011	<a href="#">FSUBR (immediate)</a>
100	<a href="#">FMAXNM (immediate)</a>
101	<a href="#">FMINNM (immediate)</a>
110	<a href="#">FMAX (immediate)</a>
111	<a href="#">FMIN (immediate)</a>

## SVE Floating Point Unary Operations - Predicated

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
01100101									0	op0				101																	

Decode fields op0	Instruction details
00x	<a href="#">SVE floating-point round to integral value</a>
010	<a href="#">SVE floating-point convert precision</a>
011	<a href="#">SVE floating-point unary operations</a>
10x	<a href="#">SVE integer convert to floating-point</a>
11x	<a href="#">SVE floating-point convert to integer</a>

## SVE floating-point round to integral value

These instructions are under [SVE Floating Point Unary Operations - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	opc	1	0	1	Pg	Zn				Zd										

Decode fields opc	Instruction Details
000	<a href="#">FRINT&lt;r&gt;</a> — <a href="#">nearest with ties to even</a>
001	<a href="#">FRINT&lt;r&gt;</a> — <a href="#">toward plus infinity</a>
010	<a href="#">FRINT&lt;r&gt;</a> — <a href="#">toward minus infinity</a>



Decode fields	Instruction Details
opc	
011	<a href="#">FRINT&lt;r&gt; — toward zero</a>
100	<a href="#">FRINT&lt;r&gt; — nearest with ties to away</a>
101	UNALLOCATED
110	<a href="#">FRINT&lt;r&gt; — current mode signalling inexact</a>
111	<a href="#">FRINT&lt;r&gt; — current mode</a>

## SVE floating-point convert precision

These instructions are under [SVE Floating Point Unary Operations - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1		opc	0	0	1	0		opc2	1	0	1		Pg					Zn				Zd		

Decode fields	Instruction Details
opc      opc2	
0x	UNALLOCATED
10	00 <a href="#">FCVT — single-precision to half-precision</a>
10	01 <a href="#">FCVT — half-precision to single-precision</a>
10	10 <a href="#">BFCVT</a>
10	11 UNALLOCATED
11	00 <a href="#">FCVT — double-precision to half-precision</a>
11	01 <a href="#">FCVT — half-precision to double-precision</a>
11	10 <a href="#">FCVT — double-precision to single-precision</a>
11	11 <a href="#">FCVT — single-precision to double-precision</a>

## SVE floating-point unary operations

These instructions are under [SVE Floating Point Unary Operations - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1		size	0	0	1	1		opc	1	0	1		Pg					Zn				Zd		

Decode fields	Instruction Details
opc	
00	<a href="#">FRECPX</a>
01	<a href="#">FSQRT</a>
1x	UNALLOCATED

## SVE integer convert to floating-point

These instructions are under [SVE Floating Point Unary Operations - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1		opc	0	1	0		opc2	U	1	0	1		Pg					Zn				Zd		

Decode fields			Instruction Details
opc	opc2	U	
00			UNALLOCATED
01	00		UNALLOCATED
01	01	0	<a href="#">SCVTF — 16-bit to half-precision</a>
01	01	1	<a href="#">UCVTF — 16-bit to half-precision</a>
01	10	0	<a href="#">SCVTF — 32-bit to half-precision</a>

Decode fields			Instruction Details
opc	opc2	U	
01	10	1	<a href="#">UCVTF — 32-bit to half-precision</a>
01	11	0	<a href="#">SCVTF — 64-bit to half-precision</a>
01	11	1	<a href="#">UCVTF — 64-bit to half-precision</a>
10	0x		UNALLOCATED
10	10	0	<a href="#">SCVTF — 32-bit to single-precision</a>
10	10	1	<a href="#">UCVTF — 32-bit to single-precision</a>
10	11		UNALLOCATED
11	00	0	<a href="#">SCVTF — 32-bit to double-precision</a>
11	00	1	<a href="#">UCVTF — 32-bit to double-precision</a>
11	01		UNALLOCATED
11	10	0	<a href="#">SCVTF — 64-bit to single-precision</a>
11	10	1	<a href="#">UCVTF — 64-bit to single-precision</a>
11	11	0	<a href="#">SCVTF — 64-bit to double-precision</a>
11	11	1	<a href="#">UCVTF — 64-bit to double-precision</a>

## SVE floating-point convert to integer

These instructions are under [SVE Floating Point Unary Operations - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	opc	0	1	1	opc2	U	1	0	1	Pg			Zn					Zd						

Decode fields			Instruction Details
opc	opc2	U	
00			UNALLOCATED
01	00		UNALLOCATED
01	01	0	<a href="#">FCVTZS — half-precision to 16-bit</a>
01	01	1	<a href="#">FCVTZU — half-precision to 16-bit</a>
01	10	0	<a href="#">FCVTZS — half-precision to 32-bit</a>
01	10	1	<a href="#">FCVTZU — half-precision to 32-bit</a>
01	11	0	<a href="#">FCVTZS — half-precision to 64-bit</a>
01	11	1	<a href="#">FCVTZU — half-precision to 64-bit</a>
10	0x		UNALLOCATED
10	10	0	<a href="#">FCVTZS — single-precision to 32-bit</a>
10	10	1	<a href="#">FCVTZU — single-precision to 32-bit</a>
10	11		UNALLOCATED
11	00	0	<a href="#">FCVTZS — double-precision to 32-bit</a>
11	00	1	<a href="#">FCVTZU — double-precision to 32-bit</a>
11	01		UNALLOCATED
11	10	0	<a href="#">FCVTZS — single-precision to 64-bit</a>
11	10	1	<a href="#">FCVTZU — single-precision to 64-bit</a>
11	11	0	<a href="#">FCVTZS — double-precision to 64-bit</a>
11	11	1	<a href="#">FCVTZU — double-precision to 64-bit</a>

## SVE floating-point recursive reduction

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	opc	0	0	1	Pg			Zn			Vd									

Decode fields opc	Instruction Details
000	<a href="#">FADDV</a>
001	UNALLOCATED
01x	UNALLOCATED
100	<a href="#">FMAXNMV</a>
101	<a href="#">FMINNMV</a>
110	<a href="#">FMAXV</a>
111	<a href="#">FMINV</a>

## SVE Floating Point Unary Operations - Unpredicated

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1			0	0	1					0	0	1		op0										

Decode fields op0	Instruction details
00	<a href="#">SVE floating-point reciprocal estimate (unpredicated)</a>
!= 00	UNALLOCATED

### SVE floating-point reciprocal estimate (unpredicated)

These instructions are under [SVE Floating Point Unary Operations - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	1		opc			0	0	1	1	0	0			Zn					Zd		

Decode fields opc	Instruction Details
0xx	UNALLOCATED
10x	UNALLOCATED
110	<a href="#">FRECPE</a>
111	<a href="#">FRSQRT</a>

## SVE Floating Point Compare - with Zero

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1			0	1	0	op0				0	0	1												

Decode fields op0	Instruction details
0	<a href="#">SVE floating-point compare with zero</a>
1	UNALLOCATED

### SVE floating-point compare with zero

These instructions are under [SVE Floating Point Compare - with Zero](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	1	0	0	eq	lt	0	0	1		Pg				Zn			ne			Pd		

Decode fields			Instruction Details
eq	lt	ne	
0	0	0	<a href="#">FCM&lt;cc&gt; (zero) — FCMGE</a>
0	0	1	<a href="#">FCM&lt;cc&gt; (zero) — FCMGT</a>
0	1	0	<a href="#">FCM&lt;cc&gt; (zero) — FCMLT</a>
0	1	1	<a href="#">FCM&lt;cc&gt; (zero) — FCMLE</a>
1		1	UNALLOCATED
1	0	0	<a href="#">FCM&lt;cc&gt; (zero) — FCMEQ</a>
1	1	0	<a href="#">FCM&lt;cc&gt; (zero) — FCMNE</a>

## SVE Floating Point Accumulating Reduction

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
01100101										011	op0			001																	

Decode fields		Instruction details
op0		
0		<a href="#">SVE floating-point serial reduction (predicated)</a>
1		UNALLOCATED

### SVE floating-point serial reduction (predicated)

These instructions are under [SVE Floating Point Accumulating Reduction](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size		0	1	1	0	opc		0	0	1		Pg					Zm				Vdn		

Decode fields		Instruction Details
opc		
00		<a href="#">FADDA</a>
01		UNALLOCATED
1x		UNALLOCATED

## SVE Floating Point Multiply-Add

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
01100101										1				op0																	

Decode fields		Instruction details
op0		
0		<a href="#">SVE floating-point multiply-accumulate writing addend</a>
1		<a href="#">SVE floating-point multiply-accumulate writing multiplicand</a>

### SVE floating-point multiply-accumulate writing addend

These instructions are under [SVE Floating Point Multiply-Add](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	1	Zm			0	opc	Pg		Zn			Zda											

Decode fields opc	Instruction Details
00	<a href="#">FMLA (vectors)</a>
01	<a href="#">FMLS (vectors)</a>
10	<a href="#">FNMLA</a>
11	<a href="#">FNMLS</a>

### SVE floating-point multiply-accumulate writing multiplicand

These instructions are under [SVE Floating Point Multiply-Add](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	1		Za		1	opc		Pg		Zm		Zdn											

Decode fields opc	Instruction Details
00	<a href="#">FMAD</a>
01	<a href="#">FMSB</a>
10	<a href="#">FNMAAD</a>
11	<a href="#">FNMSB</a>

### SVE Memory - 32-bit Gather and Unsized Contiguous

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
									op0	op1									op2								op3				

Decode fields				Instruction details	
op0	op1	op2	op3		
00	x1	0xx	0	<a href="#">SVE 32-bit gather prefetch (scalar plus 32-bit scaled offsets)</a>	
00	x1	0xx	1	UNALLOCATED	
01	x1	0xx		<a href="#">SVE 32-bit gather load halfwords (scalar plus 32-bit scaled offsets)</a>	
10	x1	0xx		<a href="#">SVE 32-bit gather load words (scalar plus 32-bit scaled offsets)</a>	
11	0x	000	0	<a href="#">LDR (predicate)</a>	
11	0x	000	1	UNALLOCATED	
11	0x	010		<a href="#">LDR (vector)</a>	
11	0x	0x1		UNALLOCATED	
11	1x	0xx	0	<a href="#">SVE contiguous prefetch (scalar plus immediate)</a>	
11	1x	0xx	1	UNALLOCATED	
!= 11	x0	0xx		<a href="#">SVE 32-bit gather load (scalar plus 32-bit unscaled offsets)</a>	
	00	10x		UNALLOCATED	
	00	110	0	<a href="#">SVE contiguous prefetch (scalar plus scalar)</a>	
	00	111	0	<a href="#">SVE 32-bit gather prefetch (vector plus immediate)</a>	
	00	11x	1	UNALLOCATED	
	01	1xx		<a href="#">SVE 32-bit gather load (vector plus immediate)</a>	
	1x	1xx		<a href="#">SVE load and broadcast element</a>	

### SVE 32-bit gather prefetch (scalar plus 32-bit scaled offsets)

These instructions are under [SVE Memory - 32-bit Gather and Unsized Contiguous](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	0	xs	1			Zm		0	msz		Pg						Rn		0			prfop		

Decode fields msz	Instruction Details
00	<a href="#">PRFB (scalar plus vector)</a>
01	<a href="#">PRFH (scalar plus vector)</a>
10	<a href="#">PRFW (scalar plus vector)</a>
11	<a href="#">PRFD (scalar plus vector)</a>

### SVE 32-bit gather load halfwords (scalar plus 32-bit scaled offsets)

These instructions are under [SVE Memory - 32-bit Gather and Unsized Contiguous](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	1	xs	1			Zm		0	U	ff		Pg						Rn				Zt		

Decode fields U	ff	Instruction Details
0	0	<a href="#">LD1SH (scalar plus vector)</a>
0	1	<a href="#">LDF1SH (scalar plus vector)</a>
1	0	<a href="#">LD1H (scalar plus vector)</a>
1	1	<a href="#">LDF1H (scalar plus vector)</a>

### SVE 32-bit gather load words (scalar plus 32-bit scaled offsets)

These instructions are under [SVE Memory - 32-bit Gather and Unsized Contiguous](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	1	0	xs	1			Zm		0	U	ff		Pg						Rn				Zt		

Decode fields U	ff	Instruction Details
0		UNALLOCATED
1	0	<a href="#">LD1W (scalar plus vector)</a>
1	1	<a href="#">LDF1W (scalar plus vector)</a>

### SVE contiguous prefetch (scalar plus immediate)

These instructions are under [SVE Memory - 32-bit Gather and Unsized Contiguous](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	1	1	1				imm6		0	msz		Pg							Rn		0		prfop		

Decode fields msz	Instruction Details
00	<a href="#">PRFB (scalar plus immediate)</a>
01	<a href="#">PRFH (scalar plus immediate)</a>
10	<a href="#">PRFW (scalar plus immediate)</a>
11	<a href="#">PRFD (scalar plus immediate)</a>

### SVE 32-bit gather load (scalar plus 32-bit unscaled offsets)

These instructions are under [SVE Memory - 32-bit Gather and Unsized Contiguous](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	!= 11	xs	0				Zm		0	U	ff		Pg						Rn				Zt		

opc

The following constraints also apply to this encoding: opc != 11 && opc != 11

Decode fields			Instruction Details
opc	U	ff	
00	0	0	<a href="#">LD1SB (scalar plus vector)</a>
00	0	1	<a href="#">LDFF1SB (scalar plus vector)</a>
00	1	0	<a href="#">LD1B (scalar plus vector)</a>
00	1	1	<a href="#">LDFF1B (scalar plus vector)</a>
01	0	0	<a href="#">LD1SH (scalar plus vector)</a>
01	0	1	<a href="#">LDFF1SH (scalar plus vector)</a>
01	1	0	<a href="#">LD1H (scalar plus vector)</a>
01	1	1	<a href="#">LDFF1H (scalar plus vector)</a>
10	0		UNALLOCATED
10	1	0	<a href="#">LD1W (scalar plus vector)</a>
10	1	1	<a href="#">LDFF1W (scalar plus vector)</a>

### SVE contiguous prefetch (scalar plus scalar)

These instructions are under [SVE Memory - 32-bit Gather and Unsized Contiguous](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	msz	0	0				Rm			1	1	0		Pg					Rn		0		prfop		

Decode fields		Instruction Details
msz		
00		<a href="#">PRFB (scalar plus scalar)</a>
01		<a href="#">PRFH (scalar plus scalar)</a>
10		<a href="#">PRFW (scalar plus scalar)</a>
11		<a href="#">PRFD (scalar plus scalar)</a>

### SVE 32-bit gather prefetch (vector plus immediate)

These instructions are under [SVE Memory - 32-bit Gather and Unsized Contiguous](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	msz	0	0				imm5			1	1	1		Pg					Zn		0		prfop		

Decode fields		Instruction Details
msz		
00		<a href="#">PRFB (vector plus immediate)</a>
01		<a href="#">PRFH (vector plus immediate)</a>
10		<a href="#">PRFW (vector plus immediate)</a>
11		<a href="#">PRFD (vector plus immediate)</a>

### SVE 32-bit gather load (vector plus immediate)

These instructions are under [SVE Memory - 32-bit Gather and Unsized Contiguous](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	msz	0	1				imm5			1	U	ff		Pg					Zn				Zt		

Decode fields			Instruction Details
msz	U	ff	
00	0	0	<a href="#">LD1SB (vector plus immediate)</a>
00	0	1	<a href="#">LDFF1SB (vector plus immediate)</a>
00	1	0	<a href="#">LD1B (vector plus immediate)</a>
00	1	1	<a href="#">LDFF1B (vector plus immediate)</a>
01	0	0	<a href="#">LD1SH (vector plus immediate)</a>
01	0	1	<a href="#">LDFF1SH (vector plus immediate)</a>
01	1	0	<a href="#">LD1H (vector plus immediate)</a>
01	1	1	<a href="#">LDFF1H (vector plus immediate)</a>
10	0		UNALLOCATED
10	1	0	<a href="#">LD1W (vector plus immediate)</a>
10	1	1	<a href="#">LDFF1W (vector plus immediate)</a>
11			UNALLOCATED

## SVE load and broadcast element

These instructions are under [SVE Memory - 32-bit Gather and Unsized Contiguous](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	dtypeh	1	imm6						1	dtypel	Pg			Rn				Zt							

Decode fields		Instruction Details
dtypeh	dtypel	
00	00	<a href="#">LD1RB — 8-bit element</a>
00	01	<a href="#">LD1RB — 16-bit element</a>
00	10	<a href="#">LD1RB — 32-bit element</a>
00	11	<a href="#">LD1RB — 64-bit element</a>
01	00	<a href="#">LD1RSW</a>
01	01	<a href="#">LD1RH — 16-bit element</a>
01	10	<a href="#">LD1RH — 32-bit element</a>
01	11	<a href="#">LD1RH — 64-bit element</a>
10	00	<a href="#">LD1RSH — 64-bit element</a>
10	01	<a href="#">LD1RSH — 32-bit element</a>
10	10	<a href="#">LD1RW — 32-bit element</a>
10	11	<a href="#">LD1RW — 64-bit element</a>
11	00	<a href="#">LD1RSB — 64-bit element</a>
11	01	<a href="#">LD1RSB — 32-bit element</a>
11	10	<a href="#">LD1RSB — 16-bit element</a>
11	11	<a href="#">LD1RD</a>

## SVE Memory - Contiguous Load

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1010010									op0	op1						op2															

Decode fields			Instruction details
op0	op1	op2	
00	0	111	<a href="#">SVE contiguous non-temporal load (scalar plus immediate)</a>
00		110	<a href="#">SVE contiguous non-temporal load (scalar plus scalar)</a>



!= 00	0	111	<a href="#">SVE load multiple structures (scalar plus immediate)</a>
!= 00		110	<a href="#">SVE load multiple structures (scalar plus scalar)</a>
	0	001	<a href="#">SVE load and broadcast quadword (scalar plus immediate)</a>
	0	101	<a href="#">SVE contiguous load (scalar plus immediate)</a>
	1	001	UNALLOCATED
	1	101	<a href="#">SVE contiguous non-fault load (scalar plus immediate)</a>
	1	111	UNALLOCATED
		000	<a href="#">SVE load and broadcast quadword (scalar plus scalar)</a>
		010	<a href="#">SVE contiguous load (scalar plus scalar)</a>
		011	<a href="#">SVE contiguous first-fault load (scalar plus scalar)</a>
		100	UNALLOCATED

### SVE contiguous non-temporal load (scalar plus immediate)

These instructions are under [SVE Memory - Contiguous Load](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	msz	0	0	0		imm4				1	1	1		Pg				Rn					Zt		

Decode fields msz	Instruction Details
00	<a href="#">LDNT1B (scalar plus immediate)</a>
01	<a href="#">LDNT1H (scalar plus immediate)</a>
10	<a href="#">LDNT1W (scalar plus immediate)</a>
11	<a href="#">LDNT1D (scalar plus immediate)</a>

### SVE contiguous non-temporal load (scalar plus scalar)

These instructions are under [SVE Memory - Contiguous Load](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	msz	0	0			Rm				1	1	0		Pg				Rn					Zt		

Decode fields msz	Instruction Details
00	<a href="#">LDNT1B (scalar plus scalar)</a>
01	<a href="#">LDNT1H (scalar plus scalar)</a>
10	<a href="#">LDNT1W (scalar plus scalar)</a>
11	<a href="#">LDNT1D (scalar plus scalar)</a>

### SVE load multiple structures (scalar plus immediate)

These instructions are under [SVE Memory - Contiguous Load](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	msz	!= 00	0		imm4					1	1	1		Pg				Rn					Zt		
opc																															

The following constraints also apply to this encoding: `opc != 00 && opc != 00`

Decode fields msz opc	Instruction Details
00 01	<a href="#">LD2B (scalar plus immediate)</a>
00 10	<a href="#">LD3B (scalar plus immediate)</a>

Decode fields		Instruction Details
msz	opc	
00	11	<a href="#">LD4B (scalar plus immediate)</a>
01	01	<a href="#">LD2H (scalar plus immediate)</a>
01	10	<a href="#">LD3H (scalar plus immediate)</a>
01	11	<a href="#">LD4H (scalar plus immediate)</a>
10	01	<a href="#">LD2W (scalar plus immediate)</a>
10	10	<a href="#">LD3W (scalar plus immediate)</a>
10	11	<a href="#">LD4W (scalar plus immediate)</a>
11	01	<a href="#">LD2D (scalar plus immediate)</a>
11	10	<a href="#">LD3D (scalar plus immediate)</a>
11	11	<a href="#">LD4D (scalar plus immediate)</a>

### SVE load multiple structures (scalar plus scalar)

These instructions are under [SVE Memory - Contiguous Load](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	msz		!= 00		Rm				1	1	0	Pg		Rn				Zt							
opc																															

The following constraints also apply to this encoding: opc != 00 && opc != 00

Decode fields		Instruction Details
msz	opc	
00	01	<a href="#">LD2B (scalar plus scalar)</a>
00	10	<a href="#">LD3B (scalar plus scalar)</a>
00	11	<a href="#">LD4B (scalar plus scalar)</a>
01	01	<a href="#">LD2H (scalar plus scalar)</a>
01	10	<a href="#">LD3H (scalar plus scalar)</a>
01	11	<a href="#">LD4H (scalar plus scalar)</a>
10	01	<a href="#">LD2W (scalar plus scalar)</a>
10	10	<a href="#">LD3W (scalar plus scalar)</a>
10	11	<a href="#">LD4W (scalar plus scalar)</a>
11	01	<a href="#">LD2D (scalar plus scalar)</a>
11	10	<a href="#">LD3D (scalar plus scalar)</a>
11	11	<a href="#">LD4D (scalar plus scalar)</a>

### SVE load and broadcast quadword (scalar plus immediate)

These instructions are under [SVE Memory - Contiguous Load](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	msz		ssz	0	imm4				0	0	1	Pg		Rn				Zt							

Decode fields		Instruction Details
msz	ssz	
	1x	UNALLOCATED
00	00	<a href="#">LD1RQB (scalar plus immediate)</a>
00	01	<a href="#">LD1ROB (scalar plus immediate)</a>
01	00	<a href="#">LD1RQH (scalar plus immediate)</a>
01	01	<a href="#">LD1ROH (scalar plus immediate)</a>
10	00	<a href="#">LD1RQW (scalar plus immediate)</a>

Decode fields		Instruction Details
msz	ssz	
10	01	<a href="#">LD1ROW (scalar plus immediate)</a>
11	00	<a href="#">LD1ROD (scalar plus immediate)</a>
11	01	<a href="#">LD1ROD (scalar plus immediate)</a>

**SVE contiguous load (scalar plus immediate)**

These instructions are under [SVE Memory - Contiguous Load](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	dtype			0	imm4				1	0	1	Pg			Rn				Zt						

Decode fields dtype	Instruction Details
0000	<a href="#">LD1B (scalar plus immediate) — 8-bit element</a>
0001	<a href="#">LD1B (scalar plus immediate) — 16-bit element</a>
0010	<a href="#">LD1B (scalar plus immediate) — 32-bit element</a>
0011	<a href="#">LD1B (scalar plus immediate) — 64-bit element</a>
0100	<a href="#">LD1SW (scalar plus immediate)</a>
0101	<a href="#">LD1H (scalar plus immediate) — 16-bit element</a>
0110	<a href="#">LD1H (scalar plus immediate) — 32-bit element</a>
0111	<a href="#">LD1H (scalar plus immediate) — 64-bit element</a>
1000	<a href="#">LD1SH (scalar plus immediate) — 64-bit element</a>
1001	<a href="#">LD1SH (scalar plus immediate) — 32-bit element</a>
1010	<a href="#">LD1W (scalar plus immediate) — 32-bit element</a>
1011	<a href="#">LD1W (scalar plus immediate) — 64-bit element</a>
1100	<a href="#">LD1SB (scalar plus immediate) — 64-bit element</a>
1101	<a href="#">LD1SB (scalar plus immediate) — 32-bit element</a>
1110	<a href="#">LD1SB (scalar plus immediate) — 16-bit element</a>
1111	<a href="#">LD1D (scalar plus immediate)</a>

**SVE contiguous non-fault load (scalar plus immediate)**

These instructions are under [SVE Memory - Contiguous Load](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	dtype				1	imm4				1	0	1	Pg			Rn				Zt					

Decode fields	Instruction Details
dtype	
0000	<a href="#">LDNF1B — 8-bit element</a>
0001	<a href="#">LDNF1B — 16-bit element</a>
0010	<a href="#">LDNF1B — 32-bit element</a>
0011	<a href="#">LDNF1B — 64-bit element</a>
0100	<a href="#">LDNF1SW</a>
0101	<a href="#">LDNF1H — 16-bit element</a>
0110	<a href="#">LDNF1H — 32-bit element</a>
0111	<a href="#">LDNF1H — 64-bit element</a>
1000	<a href="#">LDNF1SH — 64-bit element</a>
1001	<a href="#">LDNF1SH — 32-bit element</a>
1010	<a href="#">LDNF1W — 32-bit element</a>

Decode fields dtype	Instruction Details
1011	<a href="#">LDNF1W — 64-bit element</a>
1100	<a href="#">LDNF1SB — 64-bit element</a>
1101	<a href="#">LDNF1SB — 32-bit element</a>
1110	<a href="#">LDNF1SB — 16-bit element</a>
1111	<a href="#">LDNF1D</a>

### SVE load and broadcast quadword (scalar plus scalar)

These instructions are under [SVE Memory - Contiguous Load](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	msz		ssz		Rm				0	0	0	Pg		Rn				Zt							

Decode fields msz	ssz	Instruction Details
	1x	UNALLOCATED
00	00	<a href="#">LD1RQB (scalar plus scalar)</a>
00	01	<a href="#">LD1ROB (scalar plus scalar)</a>
01	00	<a href="#">LD1RQH (scalar plus scalar)</a>
01	01	<a href="#">LD1ROH (scalar plus scalar)</a>
10	00	<a href="#">LD1RQW (scalar plus scalar)</a>
10	01	<a href="#">LD1ROW (scalar plus scalar)</a>
11	00	<a href="#">LD1RQD (scalar plus scalar)</a>
11	01	<a href="#">LD1ROD (scalar plus scalar)</a>

### SVE contiguous load (scalar plus scalar)

These instructions are under [SVE Memory - Contiguous Load](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	dtype				Rm				0	1	0	Pg		Rn				Zt							

Decode fields dtype	Instruction Details
0000	<a href="#">LD1B (scalar plus scalar) — 8-bit element</a>
0001	<a href="#">LD1B (scalar plus scalar) — 16-bit element</a>
0010	<a href="#">LD1B (scalar plus scalar) — 32-bit element</a>
0011	<a href="#">LD1B (scalar plus scalar) — 64-bit element</a>
0100	<a href="#">LD1SW (scalar plus scalar)</a>
0101	<a href="#">LD1H (scalar plus scalar) — 16-bit element</a>
0110	<a href="#">LD1H (scalar plus scalar) — 32-bit element</a>
0111	<a href="#">LD1H (scalar plus scalar) — 64-bit element</a>
1000	<a href="#">LD1SH (scalar plus scalar) — 64-bit element</a>
1001	<a href="#">LD1SH (scalar plus scalar) — 32-bit element</a>
1010	<a href="#">LD1W (scalar plus scalar) — 32-bit element</a>
1011	<a href="#">LD1W (scalar plus scalar) — 64-bit element</a>
1100	<a href="#">LD1SB (scalar plus scalar) — 64-bit element</a>
1101	<a href="#">LD1SB (scalar plus scalar) — 32-bit element</a>
1110	<a href="#">LD1SB (scalar plus scalar) — 16-bit element</a>
1111	<a href="#">LD1D (scalar plus scalar)</a>

**SVE contiguous first-fault load (scalar plus scalar)**

These instructions are under [SVE Memory - Contiguous Load](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	dtype				Rm				0	1	1	Pg			Rn				Zt						

Decode fields dtype	Instruction Details
0000	<a href="#">LDFF1B (scalar plus scalar) — 8-bit element</a>
0001	<a href="#">LDFF1B (scalar plus scalar) — 16-bit element</a>
0010	<a href="#">LDFF1B (scalar plus scalar) — 32-bit element</a>
0011	<a href="#">LDFF1B (scalar plus scalar) — 64-bit element</a>
0100	<a href="#">LDFF1SW (scalar plus scalar)</a>
0101	<a href="#">LDFF1H (scalar plus scalar) — 16-bit element</a>
0110	<a href="#">LDFF1H (scalar plus scalar) — 32-bit element</a>
0111	<a href="#">LDFF1H (scalar plus scalar) — 64-bit element</a>
1000	<a href="#">LDFF1SH (scalar plus scalar) — 64-bit element</a>
1001	<a href="#">LDFF1SH (scalar plus scalar) — 32-bit element</a>
1010	<a href="#">LDFF1W (scalar plus scalar) — 32-bit element</a>
1011	<a href="#">LDFF1W (scalar plus scalar) — 64-bit element</a>
1100	<a href="#">LDFF1SB (scalar plus scalar) — 64-bit element</a>
1101	<a href="#">LDFF1SB (scalar plus scalar) — 32-bit element</a>
1110	<a href="#">LDFF1SB (scalar plus scalar) — 16-bit element</a>
1111	<a href="#">LDFF1D (scalar plus scalar)</a>

**SVE Memory - 64-bit Gather**

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1100010							op0		op1						op2									op3							

Decode fields				Instruction details
op0	op1	op2	op3	
00	01	0xx	1	UNALLOCATED
00	11	1xx	0	<a href="#">SVE 64-bit gather prefetch (scalar plus 64-bit scaled offsets)</a>
00	11		1	UNALLOCATED
00	x1	0xx	0	<a href="#">SVE 64-bit gather prefetch (scalar plus unpacked 32-bit scaled offsets)</a>
!= 00	11	1xx		<a href="#">SVE 64-bit gather load (scalar plus 64-bit scaled offsets)</a>
!= 00	x1	0xx		<a href="#">SVE 64-bit gather load (scalar plus 32-bit unpacked scaled offsets)</a>
	00	10x		UNALLOCATED
	00	110		UNALLOCATED
	00	111	0	<a href="#">SVE 64-bit gather prefetch (vector plus immediate)</a>
	00	111	1	UNALLOCATED
	01	1xx		<a href="#">SVE 64-bit gather load (vector plus immediate)</a>
	10	1xx		<a href="#">SVE 64-bit gather load (scalar plus 64-bit unscaled offsets)</a>
	x0	0xx		<a href="#">SVE 64-bit gather load (scalar plus unpacked 32-bit unscaled offsets)</a>

**SVE 64-bit gather prefetch (scalar plus 64-bit scaled offsets)**

These instructions are under [SVE Memory - 64-bit Gather](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	1	1	Zm				1	msz		Pg		Rn				0	prfop						

Decode fields msz	Instruction Details
00	<a href="#">PRFB (scalar plus vector)</a>
01	<a href="#">PRFH (scalar plus vector)</a>
10	<a href="#">PRFW (scalar plus vector)</a>
11	<a href="#">PRFD (scalar plus vector)</a>

### SVE 64-bit gather prefetch (scalar plus unpacked 32-bit scaled offsets)

These instructions are under [SVE Memory - 64-bit Gather](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	xs	1	Zm				0	msz		Pg		Rn				0	prfop						

Decode fields msz	Instruction Details
00	<a href="#">PRFB (scalar plus vector)</a>
01	<a href="#">PRFH (scalar plus vector)</a>
10	<a href="#">PRFW (scalar plus vector)</a>
11	<a href="#">PRFD (scalar plus vector)</a>

### SVE 64-bit gather load (scalar plus 64-bit scaled offsets)

These instructions are under [SVE Memory - 64-bit Gather](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	!= 00		1	1	Zm				1	U	ff	Pg			Rn				Zt						
opc																															

The following constraints also apply to this encoding: `opc != 00 && opc != 00`

Decode fields opc	U	ff	Instruction Details
01	0	0	<a href="#">LD1SH (scalar plus vector)</a>
01	0	1	<a href="#">LDFF1SH (scalar plus vector)</a>
01	1	0	<a href="#">LD1H (scalar plus vector)</a>
01	1	1	<a href="#">LDFF1H (scalar plus vector)</a>
10	0	0	<a href="#">LD1SW (scalar plus vector)</a>
10	0	1	<a href="#">LDFF1SW (scalar plus vector)</a>
10	1	0	<a href="#">LD1W (scalar plus vector)</a>
10	1	1	<a href="#">LDFF1W (scalar plus vector)</a>
11	0		UNALLOCATED
11	1	0	<a href="#">LD1D (scalar plus vector)</a>
11	1	1	<a href="#">LDFF1D (scalar plus vector)</a>

### SVE 64-bit gather load (scalar plus 32-bit unpacked scaled offsets)

These instructions are under [SVE Memory - 64-bit Gather](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	!= 00		xs	1	Zm				0	U	ff	Pg		Rn				Zt							
opc																															

The following constraints also apply to this encoding: `opc != 00 && opc != 00`

Decode fields			Instruction Details
opc	U	ff	
01	0	0	<a href="#">LD1SH (scalar plus vector)</a>
01	0	1	<a href="#">LDFF1SH (scalar plus vector)</a>
01	1	0	<a href="#">LD1H (scalar plus vector)</a>
01	1	1	<a href="#">LDFF1H (scalar plus vector)</a>
10	0	0	<a href="#">LD1SW (scalar plus vector)</a>
10	0	1	<a href="#">LDFF1SW (scalar plus vector)</a>
10	1	0	<a href="#">LD1W (scalar plus vector)</a>
10	1	1	<a href="#">LDFF1W (scalar plus vector)</a>
11	0		UNALLOCATED
11	1	0	<a href="#">LD1D (scalar plus vector)</a>
11	1	1	<a href="#">LDFF1D (scalar plus vector)</a>

### SVE 64-bit gather prefetch (vector plus immediate)

These instructions are under [SVE Memory - 64-bit Gather](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	msz		0	0	imm5					1	1	1	Pg		Zn				0	prfop					

Decode fields		Instruction Details
msz		
00		<a href="#">PRFB (vector plus immediate)</a>
01		<a href="#">PRFH (vector plus immediate)</a>
10		<a href="#">PRFW (vector plus immediate)</a>
11		<a href="#">PRFD (vector plus immediate)</a>

### SVE 64-bit gather load (vector plus immediate)

These instructions are under [SVE Memory - 64-bit Gather](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	msz	0	1	imm5					1	U	ff	Pg		Zn				Zt							

Decode fields			Instruction Details
msz	U	ff	
00	0	0	<a href="#">LD1SB (vector plus immediate)</a>
00	0	1	<a href="#">LDFF1SB (vector plus immediate)</a>
00	1	0	<a href="#">LD1B (vector plus immediate)</a>
00	1	1	<a href="#">LDFF1B (vector plus immediate)</a>
01	0	0	<a href="#">LD1SH (vector plus immediate)</a>
01	0	1	<a href="#">LDFF1SH (vector plus immediate)</a>
01	1	0	<a href="#">LD1H (vector plus immediate)</a>
01	1	1	<a href="#">LDFF1H (vector plus immediate)</a>
10	0	0	<a href="#">LD1SW (vector plus immediate)</a>
10	0	1	<a href="#">LDFF1SW (vector plus immediate)</a>
10	1	0	<a href="#">LD1W (vector plus immediate)</a>
10	1	1	<a href="#">LDFF1W (vector plus immediate)</a>
11	0		UNALLOCATED
11	1	0	<a href="#">LD1D (vector plus immediate)</a>

Decode fields			Instruction Details
msz	U	ff	
11	1	1	<a href="#">LDFF1D (vector plus immediate)</a>

**SVE 64-bit gather load (scalar plus 64-bit unscaled offsets)**

These instructions are under [SVE Memory - 64-bit Gather](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	msz		1	0	Zm				1	U	ff	Pg			Rn				Zt						

Decode fields			Instruction Details
msz	U	ff	
00	0	0	<a href="#">LD1SB (scalar plus vector)</a>
00	0	1	<a href="#">LDFF1SB (scalar plus vector)</a>
00	1	0	<a href="#">LD1B (scalar plus vector)</a>
00	1	1	<a href="#">LDFF1B (scalar plus vector)</a>
01	0	0	<a href="#">LD1SH (scalar plus vector)</a>
01	0	1	<a href="#">LDFF1SH (scalar plus vector)</a>
01	1	0	<a href="#">LD1H (scalar plus vector)</a>
01	1	1	<a href="#">LDFF1H (scalar plus vector)</a>
10	0	0	<a href="#">LD1SW (scalar plus vector)</a>
10	0	1	<a href="#">LDFF1SW (scalar plus vector)</a>
10	1	0	<a href="#">LD1W (scalar plus vector)</a>
10	1	1	<a href="#">LDFF1W (scalar plus vector)</a>
11	0		UNALLOCATED
11	1	0	<a href="#">LD1D (scalar plus vector)</a>
11	1	1	<a href="#">LDFF1D (scalar plus vector)</a>

**SVE 64-bit gather load (scalar plus unpacked 32-bit unscaled offsets)**

These instructions are under [SVE Memory - 64-bit Gather](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	msz		xs	0	Zm				0	U	ff	Pg			Rn				Zt						

Decode fields			Instruction Details
msz	U	ff	
00	0	0	<a href="#">LD1SB (scalar plus vector)</a>
00	0	1	<a href="#">LDFF1SB (scalar plus vector)</a>
00	1	0	<a href="#">LD1B (scalar plus vector)</a>
00	1	1	<a href="#">LDFF1B (scalar plus vector)</a>
01	0	0	<a href="#">LD1SH (scalar plus vector)</a>
01	0	1	<a href="#">LDFF1SH (scalar plus vector)</a>
01	1	0	<a href="#">LD1H (scalar plus vector)</a>
01	1	1	<a href="#">LDFF1H (scalar plus vector)</a>
10	0	0	<a href="#">LD1SW (scalar plus vector)</a>
10	0	1	<a href="#">LDFF1SW (scalar plus vector)</a>
10	1	0	<a href="#">LD1W (scalar plus vector)</a>
10	1	1	<a href="#">LDFF1W (scalar plus vector)</a>
11	0		UNALLOCATED
11	1	0	<a href="#">LD1D (scalar plus vector)</a>



Decode fields			Instruction Details
msz	U	ff	
11	1	1	<a href="#">LDFF1D (scalar plus vector)</a>

## SVE Memory - Contiguous Store and Unsized Contiguous

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1110010							op0									0	op1	0								op2					

Decode fields			Instruction details
op0	op1	op2	
0xx	0		UNALLOCATED
10x	0		UNALLOCATED
110	0	0	<a href="#">STR (predicate)</a>
110	0	1	UNALLOCATED
110	1		<a href="#">STR (vector)</a>
111	0		UNALLOCATED
!= 110	1		<a href="#">SVE contiguous store (scalar plus scalar)</a>

### SVE contiguous store (scalar plus scalar)

These instructions are under [SVE Memory - Contiguous Store and Unsized Contiguous](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	!= 110		o2	Rm					0	1	0	Pg			Rn				Zt						
opc																															

The following constraints also apply to this encoding: `opc != 110 && opc != 110`

Decode fields		Instruction Details
opc	o2	
00x		<a href="#">ST1B (scalar plus scalar)</a>
01x		<a href="#">ST1H (scalar plus scalar)</a>
10x		<a href="#">ST1W (scalar plus scalar)</a>
111	0	UNALLOCATED
111	1	<a href="#">ST1D (scalar plus scalar)</a>

## SVE Memory - Non-temporal and Multi-register Store

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
1110010											op0							0	op1		1												

Decode fields		Instruction details
op0	op1	
00	1	<a href="#">SVE contiguous non-temporal store (scalar plus scalar)</a>
!= 00	1	<a href="#">SVE store multiple structures (scalar plus scalar)</a>
	0	UNALLOCATED

**SVE contiguous non-temporal store (scalar plus scalar)**

These instructions are under [SVE Memory - Non-temporal and Multi-register Store](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	msz	0	0	Rm						0	1	1	Pg			Rn				Zt					

Decode fields msz	Instruction Details
00	<a href="#">STNT1B (scalar plus scalar)</a>
01	<a href="#">STNT1H (scalar plus scalar)</a>
10	<a href="#">STNT1W (scalar plus scalar)</a>
11	<a href="#">STNT1D (scalar plus scalar)</a>

**SVE store multiple structures (scalar plus scalar)**

These instructions are under [SVE Memory - Non-temporal and Multi-register Store](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	msz		!= 00		Rm				0		1		1		Pg		Rn				Zt				
opc																															

The following constraints also apply to this encoding: opc != 00 && opc != 00

Decode fields msz opc	Instruction Details
00 01	<a href="#">ST2B (scalar plus scalar)</a>
00 10	<a href="#">ST3B (scalar plus scalar)</a>
00 11	<a href="#">ST4B (scalar plus scalar)</a>
01 01	<a href="#">ST2H (scalar plus scalar)</a>
01 10	<a href="#">ST3H (scalar plus scalar)</a>
01 11	<a href="#">ST4H (scalar plus scalar)</a>
10 01	<a href="#">ST2W (scalar plus scalar)</a>
10 10	<a href="#">ST3W (scalar plus scalar)</a>
10 11	<a href="#">ST4W (scalar plus scalar)</a>
11 01	<a href="#">ST2D (scalar plus scalar)</a>
11 10	<a href="#">ST3D (scalar plus scalar)</a>
11 11	<a href="#">ST4D (scalar plus scalar)</a>

**SVE Memory - Scatter with Optional Sign Extend**

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1110010									op0						1			0													

Decode fields op0	Instruction details
00	<a href="#">SVE 64-bit scatter store (scalar plus unpacked 32-bit unscaled offsets)</a>
01	<a href="#">SVE 64-bit scatter store (scalar plus unpacked 32-bit scaled offsets)</a>
10	<a href="#">SVE 32-bit scatter store (scalar plus 32-bit unscaled offsets)</a>
11	<a href="#">SVE 32-bit scatter store (scalar plus 32-bit scaled offsets)</a>

**SVE 64-bit scatter store (scalar plus unpacked 32-bit unscaled offsets)**

These instructions are under [SVE Memory - Scatter with Optional Sign Extend](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	msz	0	0		Zm		1	xs	0		Pg		Rn		Zt										

Decode fields msz	Instruction Details
00	<a href="#">ST1B (scalar plus vector)</a>
01	<a href="#">ST1H (scalar plus vector)</a>
10	<a href="#">ST1W (scalar plus vector)</a>
11	<a href="#">ST1D (scalar plus vector)</a>

**SVE 64-bit scatter store (scalar plus unpacked 32-bit scaled offsets)**

These instructions are under [SVE Memory - Scatter with Optional Sign Extend](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	msz	0	1		Zm		1	xs	0		Pg		Rn		Zt										

Decode fields msz	Instruction Details
00	UNALLOCATED
01	<a href="#">ST1H (scalar plus vector)</a>
10	<a href="#">ST1W (scalar plus vector)</a>
11	<a href="#">ST1D (scalar plus vector)</a>

**SVE 32-bit scatter store (scalar plus 32-bit unscaled offsets)**

These instructions are under [SVE Memory - Scatter with Optional Sign Extend](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	msz	1	0		Zm		1	xs	0		Pg		Rn		Zt										

Decode fields msz	Instruction Details
00	<a href="#">ST1B (scalar plus vector)</a>
01	<a href="#">ST1H (scalar plus vector)</a>
10	<a href="#">ST1W (scalar plus vector)</a>
11	UNALLOCATED

**SVE 32-bit scatter store (scalar plus 32-bit scaled offsets)**

These instructions are under [SVE Memory - Scatter with Optional Sign Extend](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	msz	1	1		Zm		1	xs	0		Pg		Rn		Zt										

Decode fields msz	Instruction Details
00	UNALLOCATED
01	<a href="#">ST1H (scalar plus vector)</a>
10	<a href="#">ST1W (scalar plus vector)</a>
11	UNALLOCATED

## SVE Memory - Scatter

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1110010									op0							101															

Decode fields op0	Instruction details
00	<a href="#">SVE 64-bit scatter store (scalar plus 64-bit unscaled offsets)</a>
01	<a href="#">SVE 64-bit scatter store (scalar plus 64-bit scaled offsets)</a>
10	<a href="#">SVE 64-bit scatter store (vector plus immediate)</a>
11	<a href="#">SVE 32-bit scatter store (vector plus immediate)</a>

### SVE 64-bit scatter store (scalar plus 64-bit unscaled offsets)

These instructions are under [SVE Memory - Scatter](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	msz		0	0	Zm					1	0	1	Pg			Rn				Zt					

Decode fields msz	Instruction Details
00	<a href="#">ST1B (scalar plus vector)</a>
01	<a href="#">ST1H (scalar plus vector)</a>
10	<a href="#">ST1W (scalar plus vector)</a>
11	<a href="#">ST1D (scalar plus vector)</a>

### SVE 64-bit scatter store (scalar plus 64-bit scaled offsets)

These instructions are under [SVE Memory - Scatter](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	msz		0	1	Zm					1	0	1	Pg			Rn				Zt					

Decode fields msz	Instruction Details
00	UNALLOCATED
01	<a href="#">ST1H (scalar plus vector)</a>
10	<a href="#">ST1W (scalar plus vector)</a>
11	<a href="#">ST1D (scalar plus vector)</a>

### SVE 64-bit scatter store (vector plus immediate)

These instructions are under [SVE Memory - Scatter](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	msz		1	0	imm5					1	0	1	Pg			Zn				Zt					

Decode fields msz	Instruction Details
00	<a href="#">ST1B (vector plus immediate)</a>
01	<a href="#">ST1H (vector plus immediate)</a>
10	<a href="#">ST1W (vector plus immediate)</a>
11	<a href="#">ST1D (vector plus immediate)</a>

**SVE 32-bit scatter store (vector plus immediate)**

These instructions are under [SVE Memory - Scatter](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	msz		1	1	imm5				1	0	1	Pg			Zn				Zt						

Decode fields msz	Instruction Details
00	<a href="#">ST1B (vector plus immediate)</a>
01	<a href="#">ST1H (vector plus immediate)</a>
10	<a href="#">ST1W (vector plus immediate)</a>
11	UNALLOCATED

**SVE Memory - Contiguous Store with Immediate Offset**

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1110010								op0	op1					111																	

Decode fields op0	op1	Instruction details
00	1	<a href="#">SVE contiguous non-temporal store (scalar plus immediate)</a>
!= 00	1	<a href="#">SVE store multiple structures (scalar plus immediate)</a>
	0	<a href="#">SVE contiguous store (scalar plus immediate)</a>

**SVE contiguous non-temporal store (scalar plus immediate)**

These instructions are under [SVE Memory - Contiguous Store with Immediate Offset](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	msz	0	0	1	imm4				1	1	1	Pg			Rn				Zt						

Decode fields msz	Instruction Details
00	<a href="#">STNT1B (scalar plus immediate)</a>
01	<a href="#">STNT1H (scalar plus immediate)</a>
10	<a href="#">STNT1W (scalar plus immediate)</a>
11	<a href="#">STNT1D (scalar plus immediate)</a>

**SVE store multiple structures (scalar plus immediate)**

These instructions are under [SVE Memory - Contiguous Store with Immediate Offset](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	msz		!= 00		1	imm4				1 1 1			Pg			Rn				Zt					
opc																															

The following constraints also apply to this encoding: opc != 00 && opc != 00

Decode fields msz	opc	Instruction Details
00	01	<a href="#">ST2B (scalar plus immediate)</a>
00	10	<a href="#">ST3B (scalar plus immediate)</a>
00	11	<a href="#">ST4B (scalar plus immediate)</a>

Decode fields		Instruction Details
msz	opc	
01	01	<a href="#">ST2H (scalar plus immediate)</a>
01	10	<a href="#">ST3H (scalar plus immediate)</a>
01	11	<a href="#">ST4H (scalar plus immediate)</a>
10	01	<a href="#">ST2W (scalar plus immediate)</a>
10	10	<a href="#">ST3W (scalar plus immediate)</a>
10	11	<a href="#">ST4W (scalar plus immediate)</a>
11	01	<a href="#">ST2D (scalar plus immediate)</a>
11	10	<a href="#">ST3D (scalar plus immediate)</a>
11	11	<a href="#">ST4D (scalar plus immediate)</a>

## SVE contiguous store (scalar plus immediate)

These instructions are under [SVE Memory - Contiguous Store with Immediate Offset](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	msz		size		0	imm4				1	1	1	Pg			Rn				Zt					

Decode fields		Instruction Details
msz		
00		<a href="#">ST1B (scalar plus immediate)</a>
01		<a href="#">ST1H (scalar plus immediate)</a>
10		<a href="#">ST1W (scalar plus immediate)</a>
11		<a href="#">ST1D (scalar plus immediate)</a>

## Data Processing -- Immediate

These instructions are under the [top-level](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
			100			op0																									

Decode fields		Instruction details
op0		
00x		<a href="#">PC-rel. addressing</a>
010		<a href="#">Add/subtract (immediate)</a>
011		<a href="#">Add/subtract (immediate, with tags)</a>
100		<a href="#">Logical (immediate)</a>
101		<a href="#">Move wide (immediate)</a>
110		<a href="#">Bitfield</a>
111		<a href="#">Extract</a>

## PC-rel. addressing

These instructions are under [Data Processing -- Immediate](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
op		immlo		1	0	0	0	0	immhi														Rd								

Decode fields		Instruction Details
op		
0		<a href="#">ADR</a>
1		<a href="#">ADRP</a>

**Add/subtract (immediate)**

These instructions are under [Data Processing -- Immediate](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	op	S	1	0	0	0	1	0	sh	imm12												Rn				Rd					

Decode fields			Instruction Details
sf	op	S	
0	0	0	<a href="#">ADD (immediate) — 32-bit</a>
0	0	1	<a href="#">ADDS (immediate) — 32-bit</a>
0	1	0	<a href="#">SUB (immediate) — 32-bit</a>
0	1	1	<a href="#">SUBS (immediate) — 32-bit</a>
1	0	0	<a href="#">ADD (immediate) — 64-bit</a>
1	0	1	<a href="#">ADDS (immediate) — 64-bit</a>
1	1	0	<a href="#">SUB (immediate) — 64-bit</a>
1	1	1	<a href="#">SUBS (immediate) — 64-bit</a>

**Add/subtract (immediate, with tags)**

These instructions are under [Data Processing -- Immediate](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	op	S	1	0	0	0	1	1	o2	uimm6						op3	uimm4				Rn				Rd						

Decode fields				Instruction Details	Feature
sf	op	S	o2		
			1	UNALLOCATED	-
0			0	UNALLOCATED	-
1		1	0	UNALLOCATED	-
1	0	0	0	<a href="#">ADDG</a>	FEAT_MTE
1	1	0	0	<a href="#">SUBG</a>	FEAT_MTE

**Logical (immediate)**

These instructions are under [Data Processing -- Immediate](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	opc	1	0	0	1	0	0	N	immr						imms				Rn				Rd								

Decode fields			Instruction Details
sf	opc	N	
0		1	UNALLOCATED
0	00	0	<a href="#">AND (immediate) — 32-bit</a>
0	01	0	<a href="#">ORR (immediate) — 32-bit</a>
0	10	0	<a href="#">EOR (immediate) — 32-bit</a>
0	11	0	<a href="#">ANDS (immediate) — 32-bit</a>
1	00		<a href="#">AND (immediate) — 64-bit</a>
1	01		<a href="#">ORR (immediate) — 64-bit</a>
1	10		<a href="#">EOR (immediate) — 64-bit</a>
1	11		<a href="#">ANDS (immediate) — 64-bit</a>

**Move wide (immediate)**

These instructions are under [Data Processing -- Immediate](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	opc	1	0	0	1	0	1	hw	imm16																Rd						

Decode fields			Instruction Details
sf	opc	hw	
	01		UNALLOCATED
0		1x	UNALLOCATED
0	00	0x	<a href="#">MOVN — 32-bit</a>
0	10	0x	<a href="#">MOVZ — 32-bit</a>
0	11	0x	<a href="#">MOVK — 32-bit</a>
1	00		<a href="#">MOVN — 64-bit</a>
1	10		<a href="#">MOVZ — 64-bit</a>
1	11		<a href="#">MOVK — 64-bit</a>

## Bitfield

These instructions are under [Data Processing -- Immediate](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	opc	1	0	0	1	1	0	N	immr				imms				Rn				Rd										

Decode fields			Instruction Details
sf	opc	N	
	11		UNALLOCATED
0		1	UNALLOCATED
0	00	0	<a href="#">SBFM — 32-bit</a>
0	01	0	<a href="#">BFM — 32-bit</a>
0	10	0	<a href="#">UBFM — 32-bit</a>
1		0	UNALLOCATED
1	00	1	<a href="#">SBFM — 64-bit</a>
1	01	1	<a href="#">BFM — 64-bit</a>
1	10	1	<a href="#">UBFM — 64-bit</a>

## Extract

These instructions are under [Data Processing -- Immediate](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	op21	1	0	0	1	1	1	N	o0	Rm				imms				Rn				Rd									

Decode fields					Instruction Details
sf	op21	N	o0	imms	
	x1				UNALLOCATED
	00		1		UNALLOCATED
	1x				UNALLOCATED
0				1xxxxx	UNALLOCATED
0		1			UNALLOCATED
0	00	0	0	0xxxxx	<a href="#">EXTR — 32-bit</a>
1		0			UNALLOCATED
1	00	1	0		<a href="#">EXTR — 64-bit</a>

## Branches, Exception Generating and System instructions

These instructions are under the [top-level](#).



31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
op0			101			op1																								op2	

Decode fields			Instruction details			
op0	op1	op2				
010	0xxxxxxxxxxxxxx		<a href="#">Conditional branch (immediate)</a>			
110	00xxxxxxxxxxxxxx		<a href="#">Exception generation</a>			
110	01000000110001		<a href="#">System instructions with register argument</a>			
110	01000000110010	11111	<a href="#">Hints</a>			
110	01000000110011		<a href="#">Barriers</a>			
110	0100000xxx0100		<a href="#">PSTATE</a>			
110	0100x01xxxxxxxxx		<a href="#">System instructions</a>			
110	0100x1xxxxxxxxxx		<a href="#">System register move</a>			
110	1xxxxxxxxxxxxxxx		<a href="#">Unconditional branch (register)</a>			
x00			<a href="#">Unconditional branch (immediate)</a>			
x01	0xxxxxxxxxxxxxxx		<a href="#">Compare and branch (immediate)</a>			
x01	1xxxxxxxxxxxxxxx		<a href="#">Test and branch (immediate)</a>			

### Conditional branch (immediate)

These instructions are under [Branches, Exception Generating and System instructions](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	0	1	0	01	imm19																			00	cond			

Decode fields		Instruction Details
o1	o0	
0	0	<a href="#">B.cond</a>
0	1	UNALLOCATED
1		UNALLOCATED

### Exception generation

These instructions are under [Branches, Exception Generating and System instructions](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	0	opc			imm16																op2			LL	

Decode fields			Instruction Details
opc	op2	LL	
	001		UNALLOCATED
	01x		UNALLOCATED
	1xx		UNALLOCATED
000	000	00	UNALLOCATED
000	000	01	<a href="#">SVC</a>
000	000	10	<a href="#">HVC</a>
000	000	11	<a href="#">SMC</a>
001	000	x1	UNALLOCATED
001	000	00	<a href="#">BRK</a>
001	000	1x	UNALLOCATED
010	000	x1	UNALLOCATED
010	000	00	<a href="#">HLT</a>
010	000	1x	UNALLOCATED
011	000	01	UNALLOCATED

Decode fields			Instruction Details
opc	op2	LL	
011	000	1x	UNALLOCATED
100	000		UNALLOCATED
101	000	00	UNALLOCATED
101	000	01	<a href="#">DCPS1</a>
101	000	10	<a href="#">DCPS2</a>
101	000	11	<a href="#">DCPS3</a>
110	000		UNALLOCATED
111	000		UNALLOCATED

## System instructions with register argument

These instructions are under [Branches, Exception Generating and System instructions](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	0	1	CRm			op2			Rt					

Decode fields		Instruction Details	Feature
CRm	op2		
!= 0000		UNALLOCATED	-
0000	000	<a href="#">WFET</a>	FEAT_WFxT
0000	001	<a href="#">WFIT</a>	FEAT_WFxT
0000	01x	UNALLOCATED	-
0000	1xx	UNALLOCATED	-

## Hints

These instructions are under [Branches, Exception Generating and System instructions](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	CRm			op2			1	1	1	1	1	

Decode fields		Instruction Details	Feature
CRm	op2		
		<a href="#">HINT</a>	-
0000	000	<a href="#">NOP</a>	-
0000	001	<a href="#">YIELD</a>	-
0000	010	<a href="#">WFE</a>	-
0000	011	<a href="#">WFI</a>	-
0000	100	<a href="#">SEV</a>	-
0000	101	<a href="#">SEVL</a>	-
0000	110	<a href="#">DGH</a>	FEAT_DGH
0000	111	<a href="#">XPACD, XPACI, XPACLR</a>	FEAT_PAuth
0001	000	<a href="#">PACIA, PACIA1716, PACIASP, PACIAZ, PACIZA</a> — <a href="#">PACIA1716</a>	FEAT_PAuth
0001	010	<a href="#">PACIB, PACIB1716, PACIBSP, PACIBZ, PACIZB</a> — <a href="#">PACIB1716</a>	FEAT_PAuth
0001	100	<a href="#">AUTIA, AUTIA1716, AUTIASP, AUTIAZ, AUTIZA</a> — <a href="#">AUTIA1716</a>	FEAT_PAuth
0001	110	<a href="#">AUTIB, AUTIB1716, AUTIBSP, AUTIBZ, AUTIZB</a> — <a href="#">AUTIB1716</a>	FEAT_PAuth
0010	000	<a href="#">ESB</a>	FEAT_RAS
0010	001	<a href="#">PSB CSYNC</a>	FEAT_SPE
0010	010	<a href="#">TSB CSYNC</a>	FEAT_TRF
0010	100	<a href="#">CSDB</a>	-
0011	000	<a href="#">PACIA, PACIA1716, PACIASP, PACIAZ, PACIZA</a> — <a href="#">PACIAZ</a>	FEAT_PAuth

Decode fields		Instruction Details	Feature
CRm	op2		
0011	001	<a href="#">PACIA, PACIA1716, PACIASP, PACIAZ, PACIZA</a> — <a href="#">PACIASP</a>	FEAT_PAuth
0011	010	<a href="#">PACIB, PACIB1716, PACIBSP, PACIBZ, PACIZB</a> — <a href="#">PACIBZ</a>	FEAT_PAuth
0011	011	<a href="#">PACIB, PACIB1716, PACIBSP, PACIBZ, PACIZB</a> — <a href="#">PACIBSP</a>	FEAT_PAuth
0011	100	<a href="#">AUTIA, AUTIA1716, AUTIASP, AUTIAZ, AUTIZA</a> — <a href="#">AUTIAZ</a>	FEAT_PAuth
0011	101	<a href="#">AUTIA, AUTIA1716, AUTIASP, AUTIAZ, AUTIZA</a> — <a href="#">AUTIASP</a>	FEAT_PAuth
0011	110	<a href="#">AUTIB, AUTIB1716, AUTIBSP, AUTIBZ, AUTIZB</a> — <a href="#">AUTIBZ</a>	FEAT_PAuth
0011	111	<a href="#">AUTIB, AUTIB1716, AUTIBSP, AUTIBZ, AUTIZB</a> — <a href="#">AUTIBSP</a>	FEAT_PAuth
0100	xx0	<a href="#">BTI</a>	FEAT_BTI

## Barriers

These instructions are under [Branches, Exception Generating and System instructions](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	1	CRm			op2			Rt					

Decode fields			Instruction Details	Feature
CRm	op2	Rt		
	000		UNALLOCATED	-
	001	!= 11111	UNALLOCATED	-
	010	11111	<a href="#">CLREX</a>	-
	100	11111	<a href="#">DSB</a> — <a href="#">memory barrier</a>	-
	101	11111	<a href="#">DMB</a>	-
	110	11111	<a href="#">ISB</a>	-
	111	!= 11111	UNALLOCATED	-
	111	11111	<a href="#">SB</a>	-
xx0x	001	11111	UNALLOCATED	-
xx10	001	11111	<a href="#">DSB</a> — <a href="#">Memory nXS barrier</a>	FEAT_XS
xx11	001	11111	UNALLOCATED	-
0001	011		UNALLOCATED	-
001x	011		UNALLOCATED	-
01xx	011		UNALLOCATED	-
1xxx	011		UNALLOCATED	-

## PSTATE

These instructions are under [Branches, Exception Generating and System instructions](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	op1			0			1	0	0	CRm			op2			Rt			

Decode fields			Instruction Details	Feature
op1	op2	Rt		
		!= 11111	UNALLOCATED	-
		11111	<a href="#">MSR (immediate)</a>	-
000	000	11111	<a href="#">CFINV</a>	FEAT_FlagM
000	001	11111	<a href="#">XAFLAG</a>	FEAT_FlagM2
000	010	11111	<a href="#">AXFLAG</a>	FEAT_FlagM2

## System instructions

These instructions are under [Branches, Exception Generating and System instructions](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	L	0	1	op1			CRn			CRm			op2			Rt						

Decode fields	Instruction Details
L	
0	<a href="#">SYS</a>
1	<a href="#">SYSL</a>

## System register move

These instructions are under [Branches, Exception Generating and System instructions](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	L	1	o0	op1			CRn			CRm			op2			Rt						

Decode fields	Instruction Details
L	
0	<a href="#">MSR (register)</a>
1	<a href="#">MRS</a>

## Unconditional branch (register)

These instructions are under [Branches, Exception Generating and System instructions](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	1	opc			op2			op3			Rn			op4												

Decode fields			Rn	op4	Instruction Details	Feature
opc	op2	op3				
	!= 11111				UNALLOCATED	-
0000	11111	0000000		!= 00000	UNALLOCATED	-
0000	11111	0000000		00000	<a href="#">BR</a>	-
0000	11111	0000001			UNALLOCATED	-
0000	11111	0000010		!= 11111	UNALLOCATED	-
0000	11111	0000010		11111	<a href="#">BRAA, BRAAZ, BRAB, BRABZ</a> — <a href="#">key A, zero modifier</a>	FEAT_PAuth
0000	11111	0000011		!= 11111	UNALLOCATED	-
0000	11111	0000011		11111	<a href="#">BRAA, BRAAZ, BRAB, BRABZ</a> — <a href="#">key B, zero modifier</a>	FEAT_PAuth
0000	11111	0001xx			UNALLOCATED	-
0000	11111	001xxx			UNALLOCATED	-
0000	11111	01xxxx			UNALLOCATED	-
0000	11111	1xxxxx			UNALLOCATED	-
0001	11111	0000000		!= 00000	UNALLOCATED	-
0001	11111	0000000		00000	<a href="#">BLR</a>	-
0001	11111	0000001			UNALLOCATED	-

Decode fields					Instruction Details	Feature
opc	op2	op3	Rn	op4		
0001	11111	000010		!= 11111	UNALLOCATED	-
0001	11111	000010		11111	<a href="#">BLRAA, BLRAAZ, BLRAB, BLRABZ</a> — <a href="#">key A, zero modifier</a>	FEAT_PAuth
0001	11111	000011		!= 11111	UNALLOCATED	-
0001	11111	000011		11111	<a href="#">BLRAA, BLRAAZ, BLRAB, BLRABZ</a> — <a href="#">key B, zero modifier</a>	FEAT_PAuth
0001	11111	0001xx			UNALLOCATED	-
0001	11111	001xxx			UNALLOCATED	-
0001	11111	01xxxx			UNALLOCATED	-
0001	11111	1xxxxx			UNALLOCATED	-
0010	11111	000000		!= 00000	UNALLOCATED	-
0010	11111	000000		00000	<a href="#">RET</a>	-
0010	11111	000001			UNALLOCATED	-
0010	11111	000010	!= 11111	!= 11111	UNALLOCATED	-
0010	11111	000010	11111	11111	<a href="#">RETAA, RETAB</a> — <a href="#">RETAA</a>	FEAT_PAuth
0010	11111	000011	!= 11111	!= 11111	UNALLOCATED	-
0010	11111	000011	11111	11111	<a href="#">RETAA, RETAB</a> — <a href="#">RETAB</a>	FEAT_PAuth
0010	11111	0001xx			UNALLOCATED	-
0010	11111	001xxx			UNALLOCATED	-
0010	11111	01xxxx			UNALLOCATED	-
0010	11111	1xxxxx			UNALLOCATED	-
0011	11111				UNALLOCATED	-
0100	11111	000000	!= 11111	!= 00000	UNALLOCATED	-
0100	11111	000000	!= 11111	00000	UNALLOCATED	-
0100	11111	000000	11111	!= 00000	UNALLOCATED	-
0100	11111	000000	11111	00000	<a href="#">ERET</a>	-
0100	11111	000001			UNALLOCATED	-
0100	11111	000010	!= 11111	!= 11111	UNALLOCATED	-
0100	11111	000010	!= 11111	11111	UNALLOCATED	-
0100	11111	000010	11111	!= 11111	UNALLOCATED	-
0100	11111	000010	11111	11111	<a href="#">ERETAA, ERETAB</a> — <a href="#">ERETAA</a>	FEAT_PAuth
0100	11111	000011	!= 11111	!= 11111	UNALLOCATED	-
0100	11111	000011	!= 11111	11111	UNALLOCATED	-
0100	11111	000011	11111	!= 11111	UNALLOCATED	-

Decode fields					Instruction Details	Feature
opc	op2	op3	Rn	op4		
0100	11111	000011	11111	11111	<a href="#">ERETAA, ERETAB — ERETAB</a>	FEAT_PAuth
0100	11111	0001xx			UNALLOCATED	-
0100	11111	001xxx			UNALLOCATED	-
0100	11111	01xxxx			UNALLOCATED	-
0100	11111	1xxxxx			UNALLOCATED	-
0101	11111	!= 000000			UNALLOCATED	-
0101	11111	000000	!= 11111	!= 00000	UNALLOCATED	-
0101	11111	000000	!= 11111	00000	UNALLOCATED	-
0101	11111	000000	11111	!= 00000	UNALLOCATED	-
0101	11111	000000	11111	00000	<a href="#">DRPS</a>	-
011x	11111				UNALLOCATED	-
1000	11111	00000x			UNALLOCATED	-
1000	11111	000010			<a href="#">BRAA, BRAAZ, BRAB, BRABZ — key A, register modifier</a>	FEAT_PAuth
1000	11111	000011			<a href="#">BRAA, BRAAZ, BRAB, BRABZ — key B, register modifier</a>	FEAT_PAuth
1000	11111	0001xx			UNALLOCATED	-
1000	11111	001xxx			UNALLOCATED	-
1000	11111	01xxxx			UNALLOCATED	-
1000	11111	1xxxxx			UNALLOCATED	-
1001	11111	00000x			UNALLOCATED	-
1001	11111	000010			<a href="#">BLRAA, BLRAAZ, BLRAB, BLRABZ — key A, register modifier</a>	FEAT_PAuth
1001	11111	000011			<a href="#">BLRAA, BLRAAZ, BLRAB, BLRABZ — key B, register modifier</a>	FEAT_PAuth
1001	11111	0001xx			UNALLOCATED	-
1001	11111	001xxx			UNALLOCATED	-
1001	11111	01xxxx			UNALLOCATED	-
1001	11111	1xxxxx			UNALLOCATED	-
101x	11111				UNALLOCATED	-
11xx	11111				UNALLOCATED	-

### Unconditional branch (immediate)

These instructions are under [Branches, Exception Generating and System instructions](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
op	0	0	1	0	1	imm26																									

Decode fields		Instruction Details
op		
0		<a href="#">B</a>
1		<a href="#">BL</a>

### Compare and branch (immediate)

These instructions are under [Branches, Exception Generating and System instructions](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf								imm19																				Rt			

Decode fields		Instruction Details
sf	op	
0	0	<a href="#">CBZ — 32-bit</a>
0	1	<a href="#">CBNZ — 32-bit</a>
1	0	<a href="#">CBZ — 64-bit</a>
1	1	<a href="#">CBNZ — 64-bit</a>

## Test and branch (immediate)

These instructions are under [Branches, Exception Generating and System instructions](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
b5								b40				imm14																Rt			

Decode fields		Instruction Details
op		
0		<a href="#">TBZ</a>
1		<a href="#">TBNZ</a>

## Loads and Stores

These instructions are under the [top-level](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
op0				1	op1	0	op2		op3								op4														

Decode fields					Instruction details
op0	op1	op2	op3	op4	
0x00	0	00	1xxxxx		<a href="#">Compare and swap pair</a>
0x00	1	00	000000		<a href="#">Advanced SIMD load/store multiple structures</a>
0x00	1	01	0xxxxx		<a href="#">Advanced SIMD load/store multiple structures (post-indexed)</a>
0x00	1	0x	1xxxxx		UNALLOCATED
0x00	1	10	x00000		<a href="#">Advanced SIMD load/store single structure</a>
0x00	1	11			<a href="#">Advanced SIMD load/store single structure (post-indexed)</a>
0x00	1	x0	x1xxxx		UNALLOCATED
0x00	1	x0	xx1xxx		UNALLOCATED
0x00	1	x0	xxx1xx		UNALLOCATED
0x00	1	x0	xxxx1x		UNALLOCATED
0x00	1	x0	xxxxx1		UNALLOCATED
1101	0	1x	1xxxxx		<a href="#">Load/store memory tags</a>
1x00	0	00	1xxxxx		<a href="#">Load/store exclusive pair</a>
1x00	1				UNALLOCATED
xx00	0	00	0xxxxx		<a href="#">Load/store exclusive register</a>
xx00	0	01	0xxxxx		<a href="#">Load/store ordered</a>
xx00	0	01	1xxxxx		<a href="#">Compare and swap</a>
xx01	0	1x	0xxxxx	00	<a href="#">LDAPR/STLR (unscaled immediate)</a>
xx01		0x			<a href="#">Load register (literal)</a>
xx10		00			<a href="#">Load/store no-allocate pair (offset)</a>
xx10		01			<a href="#">Load/store register pair (post-indexed)</a>
xx10		10			<a href="#">Load/store register pair (offset)</a>
xx10		11			<a href="#">Load/store register pair (pre-indexed)</a>

xx11		0x	0xxxxx	00	<a href="#">Load/store register (unscaled immediate)</a>
xx11		0x	0xxxxx	01	<a href="#">Load/store register (immediate post-indexed)</a>
xx11		0x	0xxxxx	10	<a href="#">Load/store register (unprivileged)</a>
xx11		0x	0xxxxx	11	<a href="#">Load/store register (immediate pre-indexed)</a>
xx11		0x	1xxxxx	00	<a href="#">Atomic memory operations</a>
xx11		0x	1xxxxx	10	<a href="#">Load/store register (register offset)</a>
xx11		0x	1xxxxx	x1	<a href="#">Load/store register (pac)</a>
xx11		1x			<a href="#">Load/store register (unsigned immediate)</a>

## Compare and swap pair

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	sz	0	0	1	0	0	0	0	L	1			Rs			o0			Rt2					Rn					Rt		

Decode fields				Instruction Details		Feature
sz	L	o0	Rt2			
			!= 11111	UNALLOCATED		-
0	0	0	11111	<a href="#">CASP, CASPA, CASPAL, CASPL</a> — <a href="#">32-bit CASP</a>		FEAT_LSE
0	0	1	11111	<a href="#">CASP, CASPA, CASPAL, CASPL</a> — <a href="#">32-bit CASPL</a>		FEAT_LSE
0	1	0	11111	<a href="#">CASP, CASPA, CASPAL, CASPL</a> — <a href="#">32-bit CASPA</a>		FEAT_LSE
0	1	1	11111	<a href="#">CASP, CASPA, CASPAL, CASPL</a> — <a href="#">32-bit CASPAL</a>		FEAT_LSE
1	0	0	11111	<a href="#">CASP, CASPA, CASPAL, CASPL</a> — <a href="#">64-bit CASP</a>		FEAT_LSE
1	0	1	11111	<a href="#">CASP, CASPA, CASPAL, CASPL</a> — <a href="#">64-bit CASPL</a>		FEAT_LSE
1	1	0	11111	<a href="#">CASP, CASPA, CASPAL, CASPL</a> — <a href="#">64-bit CASPA</a>		FEAT_LSE
1	1	1	11111	<a href="#">CASP, CASPA, CASPAL, CASPL</a> — <a href="#">64-bit CASPAL</a>		FEAT_LSE

## Advanced SIMD load/store multiple structures

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	0	0	L	0	0	0	0	0	0				opcode		size			Rn					Rt		

Decode fields		Instruction Details	
L	opcode		
0	0000	<a href="#">ST4 (multiple structures)</a>	
0	0001	UNALLOCATED	
0	0010	<a href="#">ST1 (multiple structures)</a> — <a href="#">four registers</a>	
0	0011	UNALLOCATED	
0	0100	<a href="#">ST3 (multiple structures)</a>	
0	0101	UNALLOCATED	
0	0110	<a href="#">ST1 (multiple structures)</a> — <a href="#">three registers</a>	
0	0111	<a href="#">ST1 (multiple structures)</a> — <a href="#">one register</a>	
0	1000	<a href="#">ST2 (multiple structures)</a>	
0	1001	UNALLOCATED	
0	1010	<a href="#">ST1 (multiple structures)</a> — <a href="#">two registers</a>	
0	1011	UNALLOCATED	
0	11xx	UNALLOCATED	
1	0000	<a href="#">LD4 (multiple structures)</a>	
1	0001	UNALLOCATED	



Decode fields		Instruction Details
L	opcode	
1	0010	<a href="#">LD1 (multiple structures)</a> — <a href="#">four registers</a>
1	0011	UNALLOCATED
1	0100	<a href="#">LD3 (multiple structures)</a>
1	0101	UNALLOCATED
1	0110	<a href="#">LD1 (multiple structures)</a> — <a href="#">three registers</a>
1	0111	<a href="#">LD1 (multiple structures)</a> — <a href="#">one register</a>
1	1000	<a href="#">LD2 (multiple structures)</a>
1	1001	UNALLOCATED
1	1010	<a href="#">LD1 (multiple structures)</a> — <a href="#">two registers</a>
1	1011	UNALLOCATED
1	11xx	UNALLOCATED

### Advanced SIMD load/store multiple structures (post-indexed)

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	0	1	L	0	Rm				opcode				size				Rn				Rt				

Decode fields		Instruction Details
L	Rm opcode	
0		0001 UNALLOCATED
0		0011 UNALLOCATED
0		0101 UNALLOCATED
0		1001 UNALLOCATED
0		1011 UNALLOCATED
0		11xx UNALLOCATED
0	!= 11111	0000 <a href="#">ST4 (multiple structures)</a> — <a href="#">register offset</a>
0	!= 11111	0010 <a href="#">ST1 (multiple structures)</a> — <a href="#">four registers, register offset</a>
0	!= 11111	0100 <a href="#">ST3 (multiple structures)</a> — <a href="#">register offset</a>
0	!= 11111	0110 <a href="#">ST1 (multiple structures)</a> — <a href="#">three registers, register offset</a>
0	!= 11111	0111 <a href="#">ST1 (multiple structures)</a> — <a href="#">one register, register offset</a>
0	!= 11111	1000 <a href="#">ST2 (multiple structures)</a> — <a href="#">register offset</a>
0	!= 11111	1010 <a href="#">ST1 (multiple structures)</a> — <a href="#">two registers, register offset</a>
0	11111	0000 <a href="#">ST4 (multiple structures)</a> — <a href="#">immediate offset</a>
0	11111	0010 <a href="#">ST1 (multiple structures)</a> — <a href="#">four registers, immediate offset</a>
0	11111	0100 <a href="#">ST3 (multiple structures)</a> — <a href="#">immediate offset</a>
0	11111	0110 <a href="#">ST1 (multiple structures)</a> — <a href="#">three registers, immediate offset</a>
0	11111	0111 <a href="#">ST1 (multiple structures)</a> — <a href="#">one register, immediate offset</a>
0	11111	1000 <a href="#">ST2 (multiple structures)</a> — <a href="#">immediate offset</a>
0	11111	1010 <a href="#">ST1 (multiple structures)</a> — <a href="#">two registers, immediate offset</a>
1		0001 UNALLOCATED
1		0011 UNALLOCATED
1		0101 UNALLOCATED
1		1001 UNALLOCATED
1		1011 UNALLOCATED
1		11xx UNALLOCATED
1	!= 11111	0000 <a href="#">LD4 (multiple structures)</a> — <a href="#">register offset</a>
1	!= 11111	0010 <a href="#">LD1 (multiple structures)</a> — <a href="#">four registers, register offset</a>

Decode fields			Instruction Details
L	Rm	opcode	
1	!= 11111	0100	<a href="#">LD3 (multiple structures)</a> — <a href="#">register offset</a>
1	!= 11111	0110	<a href="#">LD1 (multiple structures)</a> — <a href="#">three registers, register offset</a>
1	!= 11111	0111	<a href="#">LD1 (multiple structures)</a> — <a href="#">one register, register offset</a>
1	!= 11111	1000	<a href="#">LD2 (multiple structures)</a> — <a href="#">register offset</a>
1	!= 11111	1010	<a href="#">LD1 (multiple structures)</a> — <a href="#">two registers, register offset</a>
1	11111	0000	<a href="#">LD4 (multiple structures)</a> — <a href="#">immediate offset</a>
1	11111	0010	<a href="#">LD1 (multiple structures)</a> — <a href="#">four registers, immediate offset</a>
1	11111	0100	<a href="#">LD3 (multiple structures)</a> — <a href="#">immediate offset</a>
1	11111	0110	<a href="#">LD1 (multiple structures)</a> — <a href="#">three registers, immediate offset</a>
1	11111	0111	<a href="#">LD1 (multiple structures)</a> — <a href="#">one register, immediate offset</a>
1	11111	1000	<a href="#">LD2 (multiple structures)</a> — <a href="#">immediate offset</a>
1	11111	1010	<a href="#">LD1 (multiple structures)</a> — <a href="#">two registers, immediate offset</a>

### Advanced SIMD load/store single structure

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	0	L	R	0	0	0	0	0	opcode	S	size													

Decode fields					Instruction Details
L	R	opcode	S	size	
0		11x			UNALLOCATED
0	0	000			<a href="#">ST1 (single structure)</a> — <a href="#">8-bit</a>
0	0	001			<a href="#">ST3 (single structure)</a> — <a href="#">8-bit</a>
0	0	010		x0	<a href="#">ST1 (single structure)</a> — <a href="#">16-bit</a>
0	0	010		x1	UNALLOCATED
0	0	011		x0	<a href="#">ST3 (single structure)</a> — <a href="#">16-bit</a>
0	0	011		x1	UNALLOCATED
0	0	100		00	<a href="#">ST1 (single structure)</a> — <a href="#">32-bit</a>
0	0	100		1x	UNALLOCATED
0	0	100	0	01	<a href="#">ST1 (single structure)</a> — <a href="#">64-bit</a>
0	0	100	1	01	UNALLOCATED
0	0	101		00	<a href="#">ST3 (single structure)</a> — <a href="#">32-bit</a>
0	0	101		10	UNALLOCATED
0	0	101	0	01	<a href="#">ST3 (single structure)</a> — <a href="#">64-bit</a>
0	0	101	0	11	UNALLOCATED
0	0	101	1	x1	UNALLOCATED
0	1	000			<a href="#">ST2 (single structure)</a> — <a href="#">8-bit</a>
0	1	001			<a href="#">ST4 (single structure)</a> — <a href="#">8-bit</a>
0	1	010		x0	<a href="#">ST2 (single structure)</a> — <a href="#">16-bit</a>
0	1	010		x1	UNALLOCATED
0	1	011		x0	<a href="#">ST4 (single structure)</a> — <a href="#">16-bit</a>
0	1	011		x1	UNALLOCATED
0	1	100		00	<a href="#">ST2 (single structure)</a> — <a href="#">32-bit</a>
0	1	100		10	UNALLOCATED
0	1	100	0	01	<a href="#">ST2 (single structure)</a> — <a href="#">64-bit</a>
0	1	100	0	11	UNALLOCATED
0	1	100	1	x1	UNALLOCATED

Decode fields					Instruction Details
L	R	opcode	S	size	
0	1	101		00	<a href="#">ST4 (single structure) — 32-bit</a>
0	1	101		10	UNALLOCATED
0	1	101	0	01	<a href="#">ST4 (single structure) — 64-bit</a>
0	1	101	0	11	UNALLOCATED
0	1	101	1	x1	UNALLOCATED
1	0	000			<a href="#">LD1 (single structure) — 8-bit</a>
1	0	001			<a href="#">LD3 (single structure) — 8-bit</a>
1	0	010		x0	<a href="#">LD1 (single structure) — 16-bit</a>
1	0	010		x1	UNALLOCATED
1	0	011		x0	<a href="#">LD3 (single structure) — 16-bit</a>
1	0	011		x1	UNALLOCATED
1	0	100		00	<a href="#">LD1 (single structure) — 32-bit</a>
1	0	100		1x	UNALLOCATED
1	0	100	0	01	<a href="#">LD1 (single structure) — 64-bit</a>
1	0	100	1	01	UNALLOCATED
1	0	101		00	<a href="#">LD3 (single structure) — 32-bit</a>
1	0	101		10	UNALLOCATED
1	0	101	0	01	<a href="#">LD3 (single structure) — 64-bit</a>
1	0	101	0	11	UNALLOCATED
1	0	101	1	x1	UNALLOCATED
1	0	110	0		<a href="#">LD1R</a>
1	0	110	1		UNALLOCATED
1	0	111	0		<a href="#">LD3R</a>
1	0	111	1		UNALLOCATED
1	1	000			<a href="#">LD2 (single structure) — 8-bit</a>
1	1	001			<a href="#">LD4 (single structure) — 8-bit</a>
1	1	010		x0	<a href="#">LD2 (single structure) — 16-bit</a>
1	1	010		x1	UNALLOCATED
1	1	011		x0	<a href="#">LD4 (single structure) — 16-bit</a>
1	1	011		x1	UNALLOCATED
1	1	100		00	<a href="#">LD2 (single structure) — 32-bit</a>
1	1	100		10	UNALLOCATED
1	1	100	0	01	<a href="#">LD2 (single structure) — 64-bit</a>
1	1	100	0	11	UNALLOCATED
1	1	100	1	x1	UNALLOCATED
1	1	101		00	<a href="#">LD4 (single structure) — 32-bit</a>
1	1	101		10	UNALLOCATED
1	1	101	0	01	<a href="#">LD4 (single structure) — 64-bit</a>
1	1	101	0	11	UNALLOCATED
1	1	101	1	x1	UNALLOCATED
1	1	110	0		<a href="#">LD2R</a>
1	1	110	1		UNALLOCATED
1	1	111	0		<a href="#">LD4R</a>
1	1	111	1		UNALLOCATED

**Advanced SIMD load/store single structure (post-indexed)**

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	1	L	R	Rm					opcode				S	size		Rn					Rt			

Decode fields						Instruction Details
L	R	Rm	opcode	S	size	
0			11x			UNALLOCATED
0	0		010		x1	UNALLOCATED
0	0		011		x1	UNALLOCATED
0	0		100		1x	UNALLOCATED
0	0		100	1	01	UNALLOCATED
0	0		101		10	UNALLOCATED
0	0		101	0	11	UNALLOCATED
0	0		101	1	x1	UNALLOCATED
0	0	!= 11111	000			<a href="#">ST1 (single structure) — 8-bit, register offset</a>
0	0	!= 11111	001			<a href="#">ST3 (single structure) — 8-bit, register offset</a>
0	0	!= 11111	010		x0	<a href="#">ST1 (single structure) — 16-bit, register offset</a>
0	0	!= 11111	011		x0	<a href="#">ST3 (single structure) — 16-bit, register offset</a>
0	0	!= 11111	100		00	<a href="#">ST1 (single structure) — 32-bit, register offset</a>
0	0	!= 11111	100	0	01	<a href="#">ST1 (single structure) — 64-bit, register offset</a>
0	0	!= 11111	101		00	<a href="#">ST3 (single structure) — 32-bit, register offset</a>
0	0	!= 11111	101	0	01	<a href="#">ST3 (single structure) — 64-bit, register offset</a>
0	0	11111	000			<a href="#">ST1 (single structure) — 8-bit, immediate offset</a>
0	0	11111	001			<a href="#">ST3 (single structure) — 8-bit, immediate offset</a>
0	0	11111	010		x0	<a href="#">ST1 (single structure) — 16-bit, immediate offset</a>
0	0	11111	011		x0	<a href="#">ST3 (single structure) — 16-bit, immediate offset</a>
0	0	11111	100		00	<a href="#">ST1 (single structure) — 32-bit, immediate offset</a>
0	0	11111	100	0	01	<a href="#">ST1 (single structure) — 64-bit, immediate offset</a>
0	0	11111	101		00	<a href="#">ST3 (single structure) — 32-bit, immediate offset</a>
0	0	11111	101	0	01	<a href="#">ST3 (single structure) — 64-bit, immediate offset</a>
0	1		010		x1	UNALLOCATED
0	1		011		x1	UNALLOCATED
0	1		100		10	UNALLOCATED
0	1		100	0	11	UNALLOCATED
0	1		100	1	x1	UNALLOCATED
0	1		101		10	UNALLOCATED
0	1		101	0	11	UNALLOCATED
0	1		101	1	x1	UNALLOCATED
0	1	!= 11111	000			<a href="#">ST2 (single structure) — 8-bit, register offset</a>
0	1	!= 11111	001			<a href="#">ST4 (single structure) — 8-bit, register offset</a>
0	1	!= 11111	010		x0	<a href="#">ST2 (single structure) — 16-bit, register offset</a>
0	1	!= 11111	011		x0	<a href="#">ST4 (single structure) — 16-bit, register offset</a>
0	1	!= 11111	100		00	<a href="#">ST2 (single structure) — 32-bit, register offset</a>
0	1	!= 11111	100	0	01	<a href="#">ST2 (single structure) — 64-bit, register offset</a>
0	1	!= 11111	101		00	<a href="#">ST4 (single structure) — 32-bit, register offset</a>
0	1	!= 11111	101	0	01	<a href="#">ST4 (single structure) — 64-bit, register offset</a>
0	1	11111	000			<a href="#">ST2 (single structure) — 8-bit, immediate offset</a>
0	1	11111	001			<a href="#">ST4 (single structure) — 8-bit, immediate offset</a>
0	1	11111	010		x0	<a href="#">ST2 (single structure) — 16-bit, immediate offset</a>
0	1	11111	011		x0	<a href="#">ST4 (single structure) — 16-bit, immediate offset</a>
0	1	11111	100		00	<a href="#">ST2 (single structure) — 32-bit, immediate offset</a>
0	1	11111	100	0	01	<a href="#">ST2 (single structure) — 64-bit, immediate offset</a>

L	R	Decode fields		S	size	Instruction Details
		Rm	opcode			
0	1	11111	101		00	<a href="#">ST4 (single structure) — 32-bit, immediate offset</a>
0	1	11111	101	0	01	<a href="#">ST4 (single structure) — 64-bit, immediate offset</a>
1	0		010		x1	UNALLOCATED
1	0		011		x1	UNALLOCATED
1	0		100		1x	UNALLOCATED
1	0		100	1	01	UNALLOCATED
1	0		101		10	UNALLOCATED
1	0		101	0	11	UNALLOCATED
1	0		101	1	x1	UNALLOCATED
1	0		110	1		UNALLOCATED
1	0		111	1		UNALLOCATED
1	0	!= 11111	000			<a href="#">LD1 (single structure) — 8-bit, register offset</a>
1	0	!= 11111	001			<a href="#">LD3 (single structure) — 8-bit, register offset</a>
1	0	!= 11111	010		x0	<a href="#">LD1 (single structure) — 16-bit, register offset</a>
1	0	!= 11111	011		x0	<a href="#">LD3 (single structure) — 16-bit, register offset</a>
1	0	!= 11111	100		00	<a href="#">LD1 (single structure) — 32-bit, register offset</a>
1	0	!= 11111	100	0	01	<a href="#">LD1 (single structure) — 64-bit, register offset</a>
1	0	!= 11111	101		00	<a href="#">LD3 (single structure) — 32-bit, register offset</a>
1	0	!= 11111	101	0	01	<a href="#">LD3 (single structure) — 64-bit, register offset</a>
1	0	!= 11111	110	0		<a href="#">LD1R — register offset</a>
1	0	!= 11111	111	0		<a href="#">LD3R — register offset</a>
1	0	11111	000			<a href="#">LD1 (single structure) — 8-bit, immediate offset</a>
1	0	11111	001			<a href="#">LD3 (single structure) — 8-bit, immediate offset</a>
1	0	11111	010		x0	<a href="#">LD1 (single structure) — 16-bit, immediate offset</a>
1	0	11111	011		x0	<a href="#">LD3 (single structure) — 16-bit, immediate offset</a>
1	0	11111	100		00	<a href="#">LD1 (single structure) — 32-bit, immediate offset</a>
1	0	11111	100	0	01	<a href="#">LD1 (single structure) — 64-bit, immediate offset</a>
1	0	11111	101		00	<a href="#">LD3 (single structure) — 32-bit, immediate offset</a>
1	0	11111	101	0	01	<a href="#">LD3 (single structure) — 64-bit, immediate offset</a>
1	0	11111	110	0		<a href="#">LD1R — immediate offset</a>
1	0	11111	111	0		<a href="#">LD3R — immediate offset</a>
1	1		010		x1	UNALLOCATED
1	1		011		x1	UNALLOCATED
1	1		100		10	UNALLOCATED
1	1		100	0	11	UNALLOCATED
1	1		100	1	x1	UNALLOCATED
1	1		101		10	UNALLOCATED
1	1		101	0	11	UNALLOCATED
1	1		101	1	x1	UNALLOCATED
1	1		110	1		UNALLOCATED
1	1		111	1		UNALLOCATED
1	1	!= 11111	000			<a href="#">LD2 (single structure) — 8-bit, register offset</a>
1	1	!= 11111	001			<a href="#">LD4 (single structure) — 8-bit, register offset</a>
1	1	!= 11111	010		x0	<a href="#">LD2 (single structure) — 16-bit, register offset</a>
1	1	!= 11111	011		x0	<a href="#">LD4 (single structure) — 16-bit, register offset</a>
1	1	!= 11111	100		00	<a href="#">LD2 (single structure) — 32-bit, register offset</a>
1	1	!= 11111	100	0	01	<a href="#">LD2 (single structure) — 64-bit, register offset</a>

Decode fields						Instruction Details
L	R	Rm	opcode	S	size	
1	1	!= 11111	101		00	<a href="#">LD4 (single structure) — 32-bit, register offset</a>
1	1	!= 11111	101	0	01	<a href="#">LD4 (single structure) — 64-bit, register offset</a>
1	1	!= 11111	110	0		<a href="#">LD2R — register offset</a>
1	1	!= 11111	111	0		<a href="#">LD4R — register offset</a>
1	1	11111	000			<a href="#">LD2 (single structure) — 8-bit, immediate offset</a>
1	1	11111	001			<a href="#">LD4 (single structure) — 8-bit, immediate offset</a>
1	1	11111	010		x0	<a href="#">LD2 (single structure) — 16-bit, immediate offset</a>
1	1	11111	011		x0	<a href="#">LD4 (single structure) — 16-bit, immediate offset</a>
1	1	11111	100		00	<a href="#">LD2 (single structure) — 32-bit, immediate offset</a>
1	1	11111	100	0	01	<a href="#">LD2 (single structure) — 64-bit, immediate offset</a>
1	1	11111	101		00	<a href="#">LD4 (single structure) — 32-bit, immediate offset</a>
1	1	11111	101	0	01	<a href="#">LD4 (single structure) — 64-bit, immediate offset</a>
1	1	11111	110	0		<a href="#">LD2R — immediate offset</a>
1	1	11111	111	0		<a href="#">LD4R — immediate offset</a>

### Load/store memory tags

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	opc	1	imm9									op2	Rn				Rt							

opc	Decode fields imm9	op2	Instruction Details	Feature
00		01	<a href="#">STG — post-index</a>	FEAT_MTE
00		10	<a href="#">STG — signed offset</a>	FEAT_MTE
00		11	<a href="#">STG — pre-index</a>	FEAT_MTE
00	000000000	00	<a href="#">STZGM</a>	FEAT_MTE2
01		00	<a href="#">LDG</a>	FEAT_MTE
01		01	<a href="#">STZG — post-index</a>	FEAT_MTE
01		10	<a href="#">STZG — signed offset</a>	FEAT_MTE
01		11	<a href="#">STZG — pre-index</a>	FEAT_MTE
10		01	<a href="#">ST2G — post-index</a>	FEAT_MTE
10		10	<a href="#">ST2G — signed offset</a>	FEAT_MTE
10		11	<a href="#">ST2G — pre-index</a>	FEAT_MTE
10	!= 000000000	00	UNALLOCATED	-
10	000000000	00	<a href="#">STGM</a>	FEAT_MTE2
11		01	<a href="#">STZ2G — post-index</a>	FEAT_MTE
11		10	<a href="#">STZ2G — signed offset</a>	FEAT_MTE
11		11	<a href="#">STZ2G — pre-index</a>	FEAT_MTE
11	!= 000000000	00	UNALLOCATED	-
11	000000000	00	<a href="#">LDGM</a>	FEAT_MTE2

### Load/store exclusive pair

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	sz	0	0	1	0	0	0	0	L	1	Rs				o0	Rt2				Rn				Rt							

Decode fields			Instruction Details
sz	L	o0	
0	0	0	<a href="#">STXP — 32-bit</a>
0	0	1	<a href="#">STLXP — 32-bit</a>
0	1	0	<a href="#">LDXP — 32-bit</a>
0	1	1	<a href="#">LDAXP — 32-bit</a>
1	0	0	<a href="#">STXP — 64-bit</a>
1	0	1	<a href="#">STLXP — 64-bit</a>
1	1	0	<a href="#">LDXP — 64-bit</a>
1	1	1	<a href="#">LDAXP — 64-bit</a>

## Load/store exclusive register

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size	0	0	1	0	0	0	0	L	0	Rs				o0		Rt2				Rn				Rt							

Decode fields			Instruction Details
size	L	o0	
00	0	0	<a href="#">STXRB</a>
00	0	1	<a href="#">STLXRB</a>
00	1	0	<a href="#">LDXRB</a>
00	1	1	<a href="#">LDAXRB</a>
01	0	0	<a href="#">STXRH</a>
01	0	1	<a href="#">STLXRH</a>
01	1	0	<a href="#">LDXRH</a>
01	1	1	<a href="#">LDAXRH</a>
10	0	0	<a href="#">STXR — 32-bit</a>
10	0	1	<a href="#">STLXR — 32-bit</a>
10	1	0	<a href="#">LDXR — 32-bit</a>
10	1	1	<a href="#">LDAXR — 32-bit</a>
11	0	0	<a href="#">STXR — 64-bit</a>
11	0	1	<a href="#">STLXR — 64-bit</a>
11	1	0	<a href="#">LDXR — 64-bit</a>
11	1	1	<a href="#">LDAXR — 64-bit</a>

## Load/store ordered

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size	0	0	1	0	0	0	1	L	0	Rs			o0		Rt2			Rn			Rt										

Decode fields			Instruction Details	Feature
size	L	o0		
00	0	0	<a href="#">STLLRB</a>	FEAT_LOR
00	0	1	<a href="#">STLRB</a>	-
00	1	0	<a href="#">LDLARB</a>	FEAT_LOR
00	1	1	<a href="#">LDARB</a>	-
01	0	0	<a href="#">STLLRH</a>	FEAT_LOR
01	0	1	<a href="#">STLRH</a>	-

Decode fields size	L	o0	Instruction Details	Feature
01	1	0	<a href="#">LDLARH</a>	FEAT_LOR
01	1	1	<a href="#">LDARH</a>	-
10	0	0	<a href="#">STLLR — 32-bit</a>	FEAT_LOR
10	0	1	<a href="#">STLR — 32-bit</a>	-
10	1	0	<a href="#">LDLAR — 32-bit</a>	FEAT_LOR
10	1	1	<a href="#">LDAR — 32-bit</a>	-
11	0	0	<a href="#">STLLR — 64-bit</a>	FEAT_LOR
11	0	1	<a href="#">STLR — 64-bit</a>	-
11	1	0	<a href="#">LDLAR — 64-bit</a>	FEAT_LOR
11	1	1	<a href="#">LDAR — 64-bit</a>	-

## Compare and swap

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size	0	0	1	0	0	0	1	L	1				Rs			o0			Rt2					Rn					Rt		

Decode fields size	L	o0	Rt2	Instruction Details	Feature
			!= 11111	UNALLOCATED	-
00	0	0	11111	<a href="#">CASB, CASAB, CASALB, CASLB — CASB</a>	FEAT_LSE
00	0	1	11111	<a href="#">CASB, CASAB, CASALB, CASLB — CASLB</a>	FEAT_LSE
00	1	0	11111	<a href="#">CASB, CASAB, CASALB, CASLB — CASAB</a>	FEAT_LSE
00	1	1	11111	<a href="#">CASB, CASAB, CASALB, CASLB — CASALB</a>	FEAT_LSE
01	0	0	11111	<a href="#">CASH, CASAH, CASALH, CASLH — CASH</a>	FEAT_LSE
01	0	1	11111	<a href="#">CASH, CASAH, CASALH, CASLH — CASLH</a>	FEAT_LSE
01	1	0	11111	<a href="#">CASH, CASAH, CASALH, CASLH — CASAH</a>	FEAT_LSE
01	1	1	11111	<a href="#">CASH, CASAH, CASALH, CASLH — CASALH</a>	FEAT_LSE
10	0	0	11111	<a href="#">CAS, CASA, CASAL, CASL — 32-bit CAS</a>	FEAT_LSE
10	0	1	11111	<a href="#">CAS, CASA, CASAL, CASL — 32-bit CASL</a>	FEAT_LSE
10	1	0	11111	<a href="#">CAS, CASA, CASAL, CASL — 32-bit CASA</a>	FEAT_LSE
10	1	1	11111	<a href="#">CAS, CASA, CASAL, CASL — 32-bit CASAL</a>	FEAT_LSE
11	0	0	11111	<a href="#">CAS, CASA, CASAL, CASL — 64-bit CAS</a>	FEAT_LSE
11	0	1	11111	<a href="#">CAS, CASA, CASAL, CASL — 64-bit CASL</a>	FEAT_LSE
11	1	0	11111	<a href="#">CAS, CASA, CASAL, CASL — 64-bit CASA</a>	FEAT_LSE
11	1	1	11111	<a href="#">CAS, CASA, CASAL, CASL — 64-bit CASAL</a>	FEAT_LSE

## LDAPR/STLR (unscaled immediate)

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size	0	1	1	0	0	1	opc	0														0	0			Rn			Rt		

Decode fields size	opc	Instruction Details	Feature
00	00	<a href="#">STLURB</a>	FEAT_LRCPC2
00	01	<a href="#">LDAPURB</a>	FEAT_LRCPC2
00	10	<a href="#">LDAPURSB — 64-bit</a>	FEAT_LRCPC2



Decode fields size	opc	Instruction Details	Feature
00	11	<a href="#">LDAPURSB — 32-bit</a>	FEAT_LRCPC2
01	00	<a href="#">STLURH</a>	FEAT_LRCPC2
01	01	<a href="#">LDAPURH</a>	FEAT_LRCPC2
01	10	<a href="#">LDAPURSH — 64-bit</a>	FEAT_LRCPC2
01	11	<a href="#">LDAPURSH — 32-bit</a>	FEAT_LRCPC2
10	00	<a href="#">STLUR — 32-bit</a>	FEAT_LRCPC2
10	01	<a href="#">LDAPUR — 32-bit</a>	FEAT_LRCPC2
10	10	<a href="#">LDAPURSW</a>	FEAT_LRCPC2
10	11	UNALLOCATED	-
11	00	<a href="#">STLUR — 64-bit</a>	FEAT_LRCPC2
11	01	<a href="#">LDAPUR — 64-bit</a>	FEAT_LRCPC2
11	10	UNALLOCATED	-
11	11	UNALLOCATED	-

### Load register (literal)

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
opc		0	1	1	V	0	0	imm19																	Rt						

Decode fields opc	V	Instruction Details
00	0	<a href="#">LDR (literal) — 32-bit</a>
00	1	<a href="#">LDR (literal, SIMD&amp;FP) — 32-bit</a>
01	0	<a href="#">LDR (literal) — 64-bit</a>
01	1	<a href="#">LDR (literal, SIMD&amp;FP) — 64-bit</a>
10	0	<a href="#">LDRSW (literal)</a>
10	1	<a href="#">LDR (literal, SIMD&amp;FP) — 128-bit</a>
11	0	<a href="#">PRFM (literal)</a>
11	1	UNALLOCATED

### Load/store no-allocate pair (offset)

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
opc		1	0	1	V	0	0	0	L	imm7							Rt2				Rn				Rt						

Decode fields opc	V	L	Instruction Details
00	0	0	<a href="#">STNP — 32-bit</a>
00	0	1	<a href="#">LDNP — 32-bit</a>
00	1	0	<a href="#">STNP (SIMD&amp;FP) — 32-bit</a>
00	1	1	<a href="#">LDNP (SIMD&amp;FP) — 32-bit</a>
01	0		UNALLOCATED
01	1	0	<a href="#">STNP (SIMD&amp;FP) — 64-bit</a>
01	1	1	<a href="#">LDNP (SIMD&amp;FP) — 64-bit</a>
10	0	0	<a href="#">STNP — 64-bit</a>
10	0	1	<a href="#">LDNP — 64-bit</a>

Decode fields			Instruction Details
opc	V	L	
10	1	0	<a href="#">STNP (SIMD&amp;FP) — 128-bit</a>
10	1	1	<a href="#">LDNP (SIMD&amp;FP) — 128-bit</a>
11			UNALLOCATED

**Load/store register pair (post-indexed)**

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
opc	1	0	1	V	0	0	1	L	imm7							Rt2				Rn				Rt							

Decode fields			Instruction Details	Feature
opc	V	L		
00	0	0	<a href="#">STP — 32-bit</a>	-
00	0	1	<a href="#">LDP — 32-bit</a>	-
00	1	0	<a href="#">STP (SIMD&amp;FP) — 32-bit</a>	-
00	1	1	<a href="#">LDP (SIMD&amp;FP) — 32-bit</a>	-
01	0	0	<a href="#">STGP</a>	FEAT_MTE
01	0	1	<a href="#">LDPSW</a>	-
01	1	0	<a href="#">STP (SIMD&amp;FP) — 64-bit</a>	-
01	1	1	<a href="#">LDP (SIMD&amp;FP) — 64-bit</a>	-
10	0	0	<a href="#">STP — 64-bit</a>	-
10	0	1	<a href="#">LDP — 64-bit</a>	-
10	1	0	<a href="#">STP (SIMD&amp;FP) — 128-bit</a>	-
10	1	1	<a href="#">LDP (SIMD&amp;FP) — 128-bit</a>	-
11			UNALLOCATED	-

**Load/store register pair (offset)**

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
opc	1	0	1	V	0	1	0	L	imm7							Rt2				Rn				Rt							

Decode fields			Instruction Details	Feature
opc	V	L		
00	0	0	<a href="#">STP — 32-bit</a>	-
00	0	1	<a href="#">LDP — 32-bit</a>	-
00	1	0	<a href="#">STP (SIMD&amp;FP) — 32-bit</a>	-
00	1	1	<a href="#">LDP (SIMD&amp;FP) — 32-bit</a>	-
01	0	0	<a href="#">STGP</a>	FEAT_MTE
01	0	1	<a href="#">LDPSW</a>	-
01	1	0	<a href="#">STP (SIMD&amp;FP) — 64-bit</a>	-
01	1	1	<a href="#">LDP (SIMD&amp;FP) — 64-bit</a>	-
10	0	0	<a href="#">STP — 64-bit</a>	-
10	0	1	<a href="#">LDP — 64-bit</a>	-
10	1	0	<a href="#">STP (SIMD&amp;FP) — 128-bit</a>	-
10	1	1	<a href="#">LDP (SIMD&amp;FP) — 128-bit</a>	-
11			UNALLOCATED	-

**Load/store register pair (pre-indexed)**

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
opc	1	0	1	V	0	1	1	L	imm7							Rt2				Rn				Rt							

Decode fields			Instruction Details	Feature
opc	V	L		
00	0	0	<a href="#">STP — 32-bit</a>	-
00	0	1	<a href="#">LDP — 32-bit</a>	-
00	1	0	<a href="#">STP (SIMD&amp;FP) — 32-bit</a>	-
00	1	1	<a href="#">LDP (SIMD&amp;FP) — 32-bit</a>	-
01	0	0	<a href="#">STGP</a>	FEAT_MTE
01	0	1	<a href="#">LDPSW</a>	-
01	1	0	<a href="#">STP (SIMD&amp;FP) — 64-bit</a>	-
01	1	1	<a href="#">LDP (SIMD&amp;FP) — 64-bit</a>	-
10	0	0	<a href="#">STP — 64-bit</a>	-
10	0	1	<a href="#">LDP — 64-bit</a>	-
10	1	0	<a href="#">STP (SIMD&amp;FP) — 128-bit</a>	-
10	1	1	<a href="#">LDP (SIMD&amp;FP) — 128-bit</a>	-
11			UNALLOCATED	-

**Load/store register (unscaled immediate)**

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size	1	1	1	V	0	0	opc	0	imm9							0 0				Rn				Rt							

Decode fields			Instruction Details
size	V	opc	
x1	1	1x	UNALLOCATED
00	0	00	<a href="#">STURB</a>
00	0	01	<a href="#">LDURB</a>
00	0	10	<a href="#">LDURSB — 64-bit</a>
00	0	11	<a href="#">LDURSB — 32-bit</a>
00	1	00	<a href="#">STUR (SIMD&amp;FP) — 8-bit</a>
00	1	01	<a href="#">LDUR (SIMD&amp;FP) — 8-bit</a>
00	1	10	<a href="#">STUR (SIMD&amp;FP) — 128-bit</a>
00	1	11	<a href="#">LDUR (SIMD&amp;FP) — 128-bit</a>
01	0	00	<a href="#">STURH</a>
01	0	01	<a href="#">LDURH</a>
01	0	10	<a href="#">LDURSH — 64-bit</a>
01	0	11	<a href="#">LDURSH — 32-bit</a>
01	1	00	<a href="#">STUR (SIMD&amp;FP) — 16-bit</a>
01	1	01	<a href="#">LDUR (SIMD&amp;FP) — 16-bit</a>
1x	0	11	UNALLOCATED
1x	1	1x	UNALLOCATED
10	0	00	<a href="#">STUR — 32-bit</a>
10	0	01	<a href="#">LDUR — 32-bit</a>
10	0	10	<a href="#">LDURSW</a>
10	1	00	<a href="#">STUR (SIMD&amp;FP) — 32-bit</a>

Decode fields			Instruction Details
size	V	opc	
10	1	01	<a href="#">LDUR (SIMD&amp;FP) — 32-bit</a>
11	0	00	<a href="#">STUR — 64-bit</a>
11	0	01	<a href="#">LDUR — 64-bit</a>
11	0	10	<a href="#">PRFUM</a>
11	1	00	<a href="#">STUR (SIMD&amp;FP) — 64-bit</a>
11	1	01	<a href="#">LDUR (SIMD&amp;FP) — 64-bit</a>

### Load/store register (immediate post-indexed)

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size	1	1	1	V	0	0	opc	0	imm9											0	1	Rn				Rt					

Decode fields			Instruction Details
size	V	opc	
x1	1	1x	UNALLOCATED
00	0	00	<a href="#">STRB (immediate)</a>
00	0	01	<a href="#">LDRB (immediate)</a>
00	0	10	<a href="#">LDRSB (immediate) — 64-bit</a>
00	0	11	<a href="#">LDRSB (immediate) — 32-bit</a>
00	1	00	<a href="#">STR (immediate, SIMD&amp;FP) — 8-bit</a>
00	1	01	<a href="#">LDR (immediate, SIMD&amp;FP) — 8-bit</a>
00	1	10	<a href="#">STR (immediate, SIMD&amp;FP) — 128-bit</a>
00	1	11	<a href="#">LDR (immediate, SIMD&amp;FP) — 128-bit</a>
01	0	00	<a href="#">STRH (immediate)</a>
01	0	01	<a href="#">LDRH (immediate)</a>
01	0	10	<a href="#">LDRSH (immediate) — 64-bit</a>
01	0	11	<a href="#">LDRSH (immediate) — 32-bit</a>
01	1	00	<a href="#">STR (immediate, SIMD&amp;FP) — 16-bit</a>
01	1	01	<a href="#">LDR (immediate, SIMD&amp;FP) — 16-bit</a>
1x	0	11	UNALLOCATED
1x	1	1x	UNALLOCATED
10	0	00	<a href="#">STR (immediate) — 32-bit</a>
10	0	01	<a href="#">LDR (immediate) — 32-bit</a>
10	0	10	<a href="#">LDRSW (immediate)</a>
10	1	00	<a href="#">STR (immediate, SIMD&amp;FP) — 32-bit</a>
10	1	01	<a href="#">LDR (immediate, SIMD&amp;FP) — 32-bit</a>
11	0	00	<a href="#">STR (immediate) — 64-bit</a>
11	0	01	<a href="#">LDR (immediate) — 64-bit</a>
11	0	10	UNALLOCATED
11	1	00	<a href="#">STR (immediate, SIMD&amp;FP) — 64-bit</a>
11	1	01	<a href="#">LDR (immediate, SIMD&amp;FP) — 64-bit</a>

### Load/store register (unprivileged)

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size	1	1	1	V	0	0	opc	0	imm9									1	0	Rn				Rt							

Decode fields size	V	opc	Instruction Details
	1		UNALLOCATED
00	0	00	<a href="#">STTRB</a>
00	0	01	<a href="#">LDTRB</a>
00	0	10	<a href="#">LDTRSB</a> — 64-bit
00	0	11	<a href="#">LDTRSB</a> — 32-bit
01	0	00	<a href="#">STTRH</a>
01	0	01	<a href="#">LDTRH</a>
01	0	10	<a href="#">LDTRSH</a> — 64-bit
01	0	11	<a href="#">LDTRSH</a> — 32-bit
1x	0	11	UNALLOCATED
10	0	00	<a href="#">STTR</a> — 32-bit
10	0	01	<a href="#">LDTR</a> — 32-bit
10	0	10	<a href="#">LDTRSW</a>
11	0	00	<a href="#">STTR</a> — 64-bit
11	0	01	<a href="#">LDTR</a> — 64-bit
11	0	10	UNALLOCATED

### Load/store register (immediate pre-indexed)

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size		1	1	1	V	0	0	opc		0	imm9										1	1	Rn					Rt			

Decode fields size	V	opc	Instruction Details
x1	1	1x	UNALLOCATED
00	0	00	<a href="#">STRB (immediate)</a>
00	0	01	<a href="#">LDRB (immediate)</a>
00	0	10	<a href="#">LDRSB (immediate)</a> — 64-bit
00	0	11	<a href="#">LDRSB (immediate)</a> — 32-bit
00	1	00	<a href="#">STR (immediate, SIMD&amp;FP)</a> — 8-bit
00	1	01	<a href="#">LDR (immediate, SIMD&amp;FP)</a> — 8-bit
00	1	10	<a href="#">STR (immediate, SIMD&amp;FP)</a> — 128-bit
00	1	11	<a href="#">LDR (immediate, SIMD&amp;FP)</a> — 128-bit
01	0	00	<a href="#">STRH (immediate)</a>
01	0	01	<a href="#">LDRH (immediate)</a>
01	0	10	<a href="#">LDRSH (immediate)</a> — 64-bit
01	0	11	<a href="#">LDRSH (immediate)</a> — 32-bit
01	1	00	<a href="#">STR (immediate, SIMD&amp;FP)</a> — 16-bit
01	1	01	<a href="#">LDR (immediate, SIMD&amp;FP)</a> — 16-bit
1x	0	11	UNALLOCATED
1x	1	1x	UNALLOCATED
10	0	00	<a href="#">STR (immediate)</a> — 32-bit
10	0	01	<a href="#">LDR (immediate)</a> — 32-bit
10	0	10	<a href="#">LDRSW (immediate)</a>
10	1	00	<a href="#">STR (immediate, SIMD&amp;FP)</a> — 32-bit
10	1	01	<a href="#">LDR (immediate, SIMD&amp;FP)</a> — 32-bit
11	0	00	<a href="#">STR (immediate)</a> — 64-bit

Decode fields			Instruction Details
size	V	opc	
11	0	01	<a href="#">LDR (immediate) — 64-bit</a>
11	0	10	UNALLOCATED
11	1	00	<a href="#">STR (immediate, SIMD&amp;FP) — 64-bit</a>
11	1	01	<a href="#">LDR (immediate, SIMD&amp;FP) — 64-bit</a>

## Atomic memory operations

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size	1	1	1	V	0	0	A	R	1	Rs					o3	opc			0	0	Rn					Rt					

Decode fields							Instruction Details	Feature
size	V	A	R	Rs	o3	opc		
	0				1	11x	UNALLOCATED	-
	0	0			1	100	UNALLOCATED	-
	0	0	1		1	001	UNALLOCATED	-
	0	0	1		1	010	UNALLOCATED	-
	0	0	1		1	011	UNALLOCATED	-
	0	0	1		1	101	UNALLOCATED	-
	0	1	0		1	001	UNALLOCATED	-
	0	1	0		1	010	UNALLOCATED	-
	0	1	0		1	011	UNALLOCATED	-
	0	1	0		1	101	UNALLOCATED	-
	0	1	1		1	001	UNALLOCATED	-
	0	1	1		1	010	UNALLOCATED	-
	0	1	1		1	011	UNALLOCATED	-
	0	1	1		1	100	UNALLOCATED	-
	0	1	1		1	101	UNALLOCATED	-
	1						UNALLOCATED	-
00	0	0	0		0	000	<a href="#">LDADDB, LDADDAB, LDADDALB, LDADDLB — LDADDB</a>	FEAT_LSE
00	0	0	0		0	001	<a href="#">LDCLRB, LDCLRAB, LDCLRALB, LDCLRLB — LDCLRB</a>	FEAT_LSE
00	0	0	0		0	010	<a href="#">LDEORB, LDEORAB, LDEORALB, LDEORLB — LDEORB</a>	FEAT_LSE
00	0	0	0		0	011	<a href="#">LDSETB, LDSETAB, LDSETALB, LDSETLB — LDSETB</a>	FEAT_LSE
00	0	0	0		0	100	<a href="#">LDSMAXB, LDSMAXAB, LDSMAXALB, LDSMAXLB — LDSMAXB</a>	FEAT_LSE
00	0	0	0		0	101	<a href="#">LDSMINB, LDSMINAB, LDSMINALB, LDSMINLB — LDSMINB</a>	FEAT_LSE
00	0	0	0		0	110	<a href="#">LDUMAXB, LDUMAXAB, LDUMAXALB, LDUMAXLB — LDUMAXB</a>	FEAT_LSE
00	0	0	0		0	111	<a href="#">LDUMINB, LDUMINAB, LDUMINALB, LDUMINLB — LDUMINB</a>	FEAT_LSE
00	0	0	0		1	000	<a href="#">SWPB, SWPAB, SWPALB, SWPLB — SWPB</a>	FEAT_LSE
00	0	0	0		1	001	UNALLOCATED	-
00	0	0	0		1	010	UNALLOCATED	-
00	0	0	0		1	011	UNALLOCATED	-
00	0	0	0		1	101	UNALLOCATED	-

size	Decode fields				o3	opc	Instruction Details	Feature
	V	A	R	Rs				
00	0	0	1		0	000	<a href="#">LDADDB, LDADDAB, LDADDALB, LDADDLB</a> — <a href="#">LDADDLB</a>	FEAT_LSE
00	0	0	1		0	001	<a href="#">LDCLRB, LDCLRAB, LDCLRALB, LDCLRLB</a> — <a href="#">LDCLRLB</a>	FEAT_LSE
00	0	0	1		0	010	<a href="#">LDEORB, LDEORAB, LDEORALB, LDEORLB</a> — <a href="#">LDEORLB</a>	FEAT_LSE
00	0	0	1		0	011	<a href="#">LDSETB, LDSETAB, LDSETALB, LDSETLB</a> — <a href="#">LDSETLB</a>	FEAT_LSE
00	0	0	1		0	100	<a href="#">LDSMAXB, LDSMAXAB, LDSMAXALB, LDSMAXLB</a> — <a href="#">LDSMAXLB</a>	FEAT_LSE
00	0	0	1		0	101	<a href="#">LDSMINB, LDSMINAB, LDSMINALB, LDSMINLB</a> — <a href="#">LDSMINLB</a>	FEAT_LSE
00	0	0	1		0	110	<a href="#">LDUMAXB, LDUMAXAB, LDUMAXALB, LDUMAXLB</a> — <a href="#">LDUMAXLB</a>	FEAT_LSE
00	0	0	1		0	111	<a href="#">LDUMINB, LDUMINAB, LDUMINALB, LDUMINLB</a> — <a href="#">LDUMINLB</a>	FEAT_LSE
00	0	0	1		1	000	<a href="#">SWPB, SWPAB, SWPALB, SWPLB</a> — <a href="#">SWPLB</a>	FEAT_LSE
00	0	1	0		0	000	<a href="#">LDADDB, LDADDAB, LDADDALB, LDADDLB</a> — <a href="#">LDADDAB</a>	FEAT_LSE
00	0	1	0		0	001	<a href="#">LDCLRB, LDCLRAB, LDCLRALB, LDCLRLB</a> — <a href="#">LDCLRAB</a>	FEAT_LSE
00	0	1	0		0	010	<a href="#">LDEORB, LDEORAB, LDEORALB, LDEORLB</a> — <a href="#">LDEORAB</a>	FEAT_LSE
00	0	1	0		0	011	<a href="#">LDSETB, LDSETAB, LDSETALB, LDSETLB</a> — <a href="#">LDSETAB</a>	FEAT_LSE
00	0	1	0		0	100	<a href="#">LDSMAXB, LDSMAXAB, LDSMAXALB, LDSMAXLB</a> — <a href="#">LDSMAXAB</a>	FEAT_LSE
00	0	1	0		0	101	<a href="#">LDSMINB, LDSMINAB, LDSMINALB, LDSMINLB</a> — <a href="#">LDSMINAB</a>	FEAT_LSE
00	0	1	0		0	110	<a href="#">LDUMAXB, LDUMAXAB, LDUMAXALB, LDUMAXLB</a> — <a href="#">LDUMAXAB</a>	FEAT_LSE
00	0	1	0		0	111	<a href="#">LDUMINB, LDUMINAB, LDUMINALB, LDUMINLB</a> — <a href="#">LDUMINAB</a>	FEAT_LSE
00	0	1	0		1	000	<a href="#">SWPB, SWPAB, SWPALB, SWPLB</a> — <a href="#">SWPAB</a>	FEAT_LSE
00	0	1	0		1	100	<a href="#">LDAPRB</a>	FEAT_LRCPC
00	0	1	1		0	000	<a href="#">LDADDB, LDADDAB, LDADDALB, LDADDLB</a> — <a href="#">LDADDALB</a>	FEAT_LSE
00	0	1	1		0	001	<a href="#">LDCLRB, LDCLRAB, LDCLRALB, LDCLRLB</a> — <a href="#">LDCLRALB</a>	FEAT_LSE
00	0	1	1		0	010	<a href="#">LDEORB, LDEORAB, LDEORALB, LDEORLB</a> — <a href="#">LDEORALB</a>	FEAT_LSE
00	0	1	1		0	011	<a href="#">LDSETB, LDSETAB, LDSETALB, LDSETLB</a> — <a href="#">LDSETALB</a>	FEAT_LSE
00	0	1	1		0	100	<a href="#">LDSMAXB, LDSMAXAB, LDSMAXALB, LDSMAXLB</a> — <a href="#">LDSMAXALB</a>	FEAT_LSE
00	0	1	1		0	101	<a href="#">LDSMINB, LDSMINAB, LDSMINALB, LDSMINLB</a> — <a href="#">LDSMINALB</a>	FEAT_LSE
00	0	1	1		0	110	<a href="#">LDUMAXB, LDUMAXAB, LDUMAXALB, LDUMAXLB</a> — <a href="#">LDUMAXALB</a>	FEAT_LSE
00	0	1	1		0	111	<a href="#">LDUMINB, LDUMINAB, LDUMINALB, LDUMINLB</a> — <a href="#">LDUMINALB</a>	FEAT_LSE
00	0	1	1		1	000	<a href="#">SWPB, SWPAB, SWPALB, SWPLB</a> — <a href="#">SWPALB</a>	FEAT_LSE
01	0	0	0		0	000	<a href="#">LDADDB, LDADDAB, LDADDALB, LDADDLB</a> — <a href="#">LDADDH</a>	FEAT_LSE
01	0	0	0		0	001	<a href="#">LDCLRB, LDCLRAB, LDCLRALB, LDCLRLB</a> — <a href="#">LDCLRHB</a>	FEAT_LSE

size	Decode fields				o3	opc	Instruction Details	Feature
	V	A	R	Rs				
01	0	0	0		0	010	<a href="#">LDEORH, LDEORAH, LDEORALH, LDEORLH</a> — <a href="#">LDEORH</a>	FEAT_LSE
01	0	0	0		0	011	<a href="#">LDSETH, LDSETAH, LDSETALH, LDSETLH</a> — <a href="#">LDSETH</a>	FEAT_LSE
01	0	0	0		0	100	<a href="#">LDSMAXH, LDSMAXAH, LDSMAXALH, LDSMAXLH</a> — <a href="#">LDSMAXH</a>	FEAT_LSE
01	0	0	0		0	101	<a href="#">LDSMINH, LDSMINAH, LDSMINALH, LDSMINLH</a> — <a href="#">LDSMINH</a>	FEAT_LSE
01	0	0	0		0	110	<a href="#">LDUMAXH, LDUMAXAH, LDUMAXALH, LDUMAXLH</a> — <a href="#">LDUMAXH</a>	FEAT_LSE
01	0	0	0		0	111	<a href="#">LDUMINH, LDUMINAH, LDUMINALH, LDUMINLH</a> — <a href="#">LDUMINH</a>	FEAT_LSE
01	0	0	0		1	000	<a href="#">SWPH, SWPAH, SWPALH, SWPLH</a> — <a href="#">SWPH</a>	FEAT_LSE
01	0	0	0		1	001	UNALLOCATED	-
01	0	0	0		1	010	UNALLOCATED	-
01	0	0	0		1	011	UNALLOCATED	-
01	0	0	0		1	101	UNALLOCATED	-
01	0	0	1		0	000	<a href="#">LDADDH, LDADDAH, LDADDALH, LDADDLH</a> — <a href="#">LDADDLH</a>	FEAT_LSE
01	0	0	1		0	001	<a href="#">LDCLR H, LDCLRAH, LDCLR ALH, LDCLR LH</a> — <a href="#">LDCLR LH</a>	FEAT_LSE
01	0	0	1		0	010	<a href="#">LDEORH, LDEORAH, LDEORALH, LDEORLH</a> — <a href="#">LDEORLH</a>	FEAT_LSE
01	0	0	1		0	011	<a href="#">LDSETH, LDSETAH, LDSETALH, LDSETLH</a> — <a href="#">LDSETLH</a>	FEAT_LSE
01	0	0	1		0	100	<a href="#">LDSMAXH, LDSMAXAH, LDSMAXALH, LDSMAXLH</a> — <a href="#">LDSMAXLH</a>	FEAT_LSE
01	0	0	1		0	101	<a href="#">LDSMINH, LDSMINAH, LDSMINALH, LDSMINLH</a> — <a href="#">LDSMINLH</a>	FEAT_LSE
01	0	0	1		0	110	<a href="#">LDUMAXH, LDUMAXAH, LDUMAXALH, LDUMAXLH</a> — <a href="#">LDUMAXLH</a>	FEAT_LSE
01	0	0	1		0	111	<a href="#">LDUMINH, LDUMINAH, LDUMINALH, LDUMINLH</a> — <a href="#">LDUMINLH</a>	FEAT_LSE
01	0	0	1		1	000	<a href="#">SWPH, SWPAH, SWPALH, SWPLH</a> — <a href="#">SWPLH</a>	FEAT_LSE
01	0	1	0		0	000	<a href="#">LDADDH, LDADDAH, LDADDALH, LDADDLH</a> — <a href="#">LDADDAH</a>	FEAT_LSE
01	0	1	0		0	001	<a href="#">LDCLR H, LDCLRAH, LDCLR ALH, LDCLR LH</a> — <a href="#">LDCLR AH</a>	FEAT_LSE
01	0	1	0		0	010	<a href="#">LDEORH, LDEORAH, LDEORALH, LDEORLH</a> — <a href="#">LDEORAH</a>	FEAT_LSE
01	0	1	0		0	011	<a href="#">LDSETH, LDSETAH, LDSETALH, LDSETLH</a> — <a href="#">LDSETAH</a>	FEAT_LSE
01	0	1	0		0	100	<a href="#">LDSMAXH, LDSMAXAH, LDSMAXALH, LDSMAXLH</a> — <a href="#">LDSMAXAH</a>	FEAT_LSE
01	0	1	0		0	101	<a href="#">LDSMINH, LDSMINAH, LDSMINALH, LDSMINLH</a> — <a href="#">LDSMINAH</a>	FEAT_LSE
01	0	1	0		0	110	<a href="#">LDUMAXH, LDUMAXAH, LDUMAXALH, LDUMAXLH</a> — <a href="#">LDUMAXAH</a>	FEAT_LSE
01	0	1	0		0	111	<a href="#">LDUMINH, LDUMINAH, LDUMINALH, LDUMINLH</a> — <a href="#">LDUMINAH</a>	FEAT_LSE
01	0	1	0		1	000	<a href="#">SWPH, SWPAH, SWPALH, SWPLH</a> — <a href="#">SWPAH</a>	FEAT_LSE
01	0	1	0		1	100	<a href="#">LDAPRH</a>	FEAT_LRCPC
01	0	1	1		0	000	<a href="#">LDADDH, LDADDAH, LDADDALH, LDADDLH</a> — <a href="#">LDADDALH</a>	FEAT_LSE



size	Decode fields				o3	opc	Instruction Details	Feature
	V	A	R	Rs				
01	0	1	1		0	001	<a href="#">LDCLR, LDCLRA, LDCLRAL, LDCLRL — LDCLRALH</a>	FEAT_LSE
01	0	1	1		0	010	<a href="#">LDEOR, LDEORA, LDEORAL, LDEORL — LDEORALH</a>	FEAT_LSE
01	0	1	1		0	011	<a href="#">LDSETH, LDSETAH, LDSETALH, LDSETLH — LDSETALH</a>	FEAT_LSE
01	0	1	1		0	100	<a href="#">LDSMAX, LDSMAXA, LDSMAXAL, LDSMAXL — LDSMAXALH</a>	FEAT_LSE
01	0	1	1		0	101	<a href="#">LDSMIN, LDSMINA, LDSMINAL, LDSMINL — LDSMINALH</a>	FEAT_LSE
01	0	1	1		0	110	<a href="#">LDUMAX, LDUMAXA, LDUMAXAL, LDUMAXL — LDUMAXALH</a>	FEAT_LSE
01	0	1	1		0	111	<a href="#">LDUMIN, LDUMINA, LDUMINAL, LDUMINL — LDUMINALH</a>	FEAT_LSE
01	0	1	1		1	000	<a href="#">SWPH, SWPAH, SWPALH, SWPLH — SWPALH</a>	FEAT_LSE
10	0	0	0		0	000	<a href="#">LDADD, LDADDA, LDADDAL, LDADDL — 32-bit LDADD</a>	FEAT_LSE
10	0	0	0		0	001	<a href="#">LDCLR, LDCLRA, LDCLRAL, LDCLRL — 32-bit LDCLR</a>	FEAT_LSE
10	0	0	0		0	010	<a href="#">LDEOR, LDEORA, LDEORAL, LDEORL — 32-bit LDEOR</a>	FEAT_LSE
10	0	0	0		0	011	<a href="#">LDSET, LDSETA, LDSETAL, LDSETL — 32-bit LDSET</a>	FEAT_LSE
10	0	0	0		0	100	<a href="#">LDSMAX, LDSMAXA, LDSMAXAL, LDSMAXL — 32-bit LDSMAX</a>	FEAT_LSE
10	0	0	0		0	101	<a href="#">LDSMIN, LDSMINA, LDSMINAL, LDSMINL — 32-bit LDSMIN</a>	FEAT_LSE
10	0	0	0		0	110	<a href="#">LDUMAX, LDUMAXA, LDUMAXAL, LDUMAXL — 32-bit LDUMAX</a>	FEAT_LSE
10	0	0	0		0	111	<a href="#">LDUMIN, LDUMINA, LDUMINAL, LDUMINL — 32-bit LDUMIN</a>	FEAT_LSE
10	0	0	0		1	000	<a href="#">SWP, SWPA, SWPAL, SWPL — 32-bit SWP</a>	FEAT_LSE
10	0	0	0		1	001	UNALLOCATED	-
10	0	0	0		1	010	UNALLOCATED	-
10	0	0	0		1	011	UNALLOCATED	-
10	0	0	0		1	101	UNALLOCATED	-
10	0	0	1		0	000	<a href="#">LDADD, LDADDA, LDADDAL, LDADDL — 32-bit LDADDL</a>	FEAT_LSE
10	0	0	1		0	001	<a href="#">LDCLR, LDCLRA, LDCLRAL, LDCLRL — 32-bit LDCLRL</a>	FEAT_LSE
10	0	0	1		0	010	<a href="#">LDEOR, LDEORA, LDEORAL, LDEORL — 32-bit LDEORL</a>	FEAT_LSE
10	0	0	1		0	011	<a href="#">LDSET, LDSETA, LDSETAL, LDSETL — 32-bit LDSETL</a>	FEAT_LSE
10	0	0	1		0	100	<a href="#">LDSMAX, LDSMAXA, LDSMAXAL, LDSMAXL — 32-bit LDSMAXL</a>	FEAT_LSE
10	0	0	1		0	101	<a href="#">LDSMIN, LDSMINA, LDSMINAL, LDSMINL — 32-bit LDSMINL</a>	FEAT_LSE
10	0	0	1		0	110	<a href="#">LDUMAX, LDUMAXA, LDUMAXAL, LDUMAXL — 32-bit LDUMAXL</a>	FEAT_LSE
10	0	0	1		0	111	<a href="#">LDUMIN, LDUMINA, LDUMINAL, LDUMINL — 32-bit LDUMINL</a>	FEAT_LSE
10	0	0	1		1	000	<a href="#">SWP, SWPA, SWPAL, SWPL — 32-bit SWPL</a>	FEAT_LSE
10	0	1	0		0	000	<a href="#">LDADD, LDADDA, LDADDAL, LDADDL — 32-bit LDADDA</a>	FEAT_LSE

size	Decode fields				Instruction Details			Feature
	V	A	R	Rs	o3	opc		
10	0	1	0		0	001	<a href="#">LDCLR, LDCLRA, LDCLRAL, LDCLRL</a> — 32-bit <a href="#">LDCLRA</a>	FEAT_LSE
10	0	1	0		0	010	<a href="#">LDEOR, LDEORA, LDEORAL, LDEORL</a> — 32-bit <a href="#">LDEORA</a>	FEAT_LSE
10	0	1	0		0	011	<a href="#">LDSET, LDSETA, LDSETAL, LDSETL</a> — 32-bit <a href="#">LDSETA</a>	FEAT_LSE
10	0	1	0		0	100	<a href="#">LDSMAX, LDSMAXA, LDSMAXAL, LDSMAXL</a> — 32-bit <a href="#">LDSMAXA</a>	FEAT_LSE
10	0	1	0		0	101	<a href="#">LDSMIN, LDSMINA, LDSMINAL, LDSMINL</a> — 32-bit <a href="#">LDSMINA</a>	FEAT_LSE
10	0	1	0		0	110	<a href="#">LDUMAX, LDUMAXA, LDUMAXAL, LDUMAXL</a> — 32-bit <a href="#">LDUMAXA</a>	FEAT_LSE
10	0	1	0		0	111	<a href="#">LDUMIN, LDUMINA, LDUMINAL, LDUMINL</a> — 32-bit <a href="#">LDUMINA</a>	FEAT_LSE
10	0	1	0		1	000	<a href="#">SWP, SWPA, SWPAL, SWPL</a> — 32-bit <a href="#">SWPA</a>	FEAT_LSE
10	0	1	0		1	100	<a href="#">LDAPR</a> — 32-bit	FEAT_LRCPC
10	0	1	1		0	000	<a href="#">LDADD, LDADDA, LDADDAL, LDADDL</a> — 32-bit <a href="#">LDADDAL</a>	FEAT_LSE
10	0	1	1		0	001	<a href="#">LDCLR, LDCLRA, LDCLRAL, LDCLRL</a> — 32-bit <a href="#">LDCLRAL</a>	FEAT_LSE
10	0	1	1		0	010	<a href="#">LDEOR, LDEORA, LDEORAL, LDEORL</a> — 32-bit <a href="#">LDEORAL</a>	FEAT_LSE
10	0	1	1		0	011	<a href="#">LDSET, LDSETA, LDSETAL, LDSETL</a> — 32-bit <a href="#">LDSETAL</a>	FEAT_LSE
10	0	1	1		0	100	<a href="#">LDSMAX, LDSMAXA, LDSMAXAL, LDSMAXL</a> — 32-bit <a href="#">LDSMAXAL</a>	FEAT_LSE
10	0	1	1		0	101	<a href="#">LDSMIN, LDSMINA, LDSMINAL, LDSMINL</a> — 32-bit <a href="#">LDSMINAL</a>	FEAT_LSE
10	0	1	1		0	110	<a href="#">LDUMAX, LDUMAXA, LDUMAXAL, LDUMAXL</a> — 32-bit <a href="#">LDUMAXAL</a>	FEAT_LSE
10	0	1	1		0	111	<a href="#">LDUMIN, LDUMINA, LDUMINAL, LDUMINL</a> — 32-bit <a href="#">LDUMINAL</a>	FEAT_LSE
10	0	1	1		1	000	<a href="#">SWP, SWPA, SWPAL, SWPL</a> — 32-bit <a href="#">SWPAL</a>	FEAT_LSE
11	0	0	0		0	000	<a href="#">LDADD, LDADDA, LDADDAL, LDADDL</a> — 64-bit <a href="#">LDADD</a>	FEAT_LSE
11	0	0	0		0	001	<a href="#">LDCLR, LDCLRA, LDCLRAL, LDCLRL</a> — 64-bit <a href="#">LDCLR</a>	FEAT_LSE
11	0	0	0		0	010	<a href="#">LDEOR, LDEORA, LDEORAL, LDEORL</a> — 64-bit <a href="#">LDEOR</a>	FEAT_LSE
11	0	0	0		0	011	<a href="#">LDSET, LDSETA, LDSETAL, LDSETL</a> — 64-bit <a href="#">LDSET</a>	FEAT_LSE
11	0	0	0		0	100	<a href="#">LDSMAX, LDSMAXA, LDSMAXAL, LDSMAXL</a> — 64-bit <a href="#">LDSMAX</a>	FEAT_LSE
11	0	0	0		0	101	<a href="#">LDSMIN, LDSMINA, LDSMINAL, LDSMINL</a> — 64-bit <a href="#">LDSMIN</a>	FEAT_LSE
11	0	0	0		0	110	<a href="#">LDUMAX, LDUMAXA, LDUMAXAL, LDUMAXL</a> — 64-bit <a href="#">LDUMAX</a>	FEAT_LSE
11	0	0	0		0	111	<a href="#">LDUMIN, LDUMINA, LDUMINAL, LDUMINL</a> — 64-bit <a href="#">LDUMIN</a>	FEAT_LSE
11	0	0	0		1	000	<a href="#">SWP, SWPA, SWPAL, SWPL</a> — 64-bit <a href="#">SWP</a>	FEAT_LSE
11	0	0	0		1	010	<a href="#">ST64BV0</a>	FEAT_LS64_V
11	0	0	0		1	011	<a href="#">ST64BV</a>	FEAT_LS64_V
11	0	0	0	11111	1	001	<a href="#">ST64B</a>	FEAT_LS64
11	0	0	0	11111	1	101	<a href="#">LD64B</a>	FEAT_LS64

size	Decode fields							Instruction Details	Feature
	V	A	R	Rs					
11	0	0	1		0	000	<a href="#">LDADD, LDADDA, LDADDAL, LDADDL — 64-bit LDADDL</a>	FEAT_LSE	
11	0	0	1		0	001	<a href="#">LDCLR, LDCLRA, LDCLRAL, LDCLRL — 64-bit LDCLRL</a>	FEAT_LSE	
11	0	0	1		0	010	<a href="#">LDEOR, LDEORA, LDEORAL, LDEORL — 64-bit LDEORL</a>	FEAT_LSE	
11	0	0	1		0	011	<a href="#">LDSET, LDSETA, LDSETAL, LDSETL — 64-bit LDSETL</a>	FEAT_LSE	
11	0	0	1		0	100	<a href="#">LDSMAX, LDSMAXA, LDSMAXAL, LDSMAXL — 64-bit LDSMAXL</a>	FEAT_LSE	
11	0	0	1		0	101	<a href="#">LDSMIN, LDSMINA, LDSMINAL, LDSMINL — 64-bit LDSMINL</a>	FEAT_LSE	
11	0	0	1		0	110	<a href="#">LDUMAX, LDUMAXA, LDUMAXAL, LDUMAXL — 64-bit LDUMAXL</a>	FEAT_LSE	
11	0	0	1		0	111	<a href="#">LDUMIN, LDUMINA, LDUMINAL, LDUMINL — 64-bit LDUMINL</a>	FEAT_LSE	
11	0	0	1		1	000	<a href="#">SWP, SWPA, SWPAL, SWPL — 64-bit SWPL</a>	FEAT_LSE	
11	0	1	0		0	000	<a href="#">LDADD, LDADDA, LDADDAL, LDADDL — 64-bit LDADDA</a>	FEAT_LSE	
11	0	1	0		0	001	<a href="#">LDCLR, LDCLRA, LDCLRAL, LDCLRL — 64-bit LDCLRA</a>	FEAT_LSE	
11	0	1	0		0	010	<a href="#">LDEOR, LDEORA, LDEORAL, LDEORL — 64-bit LDEORA</a>	FEAT_LSE	
11	0	1	0		0	011	<a href="#">LDSET, LDSETA, LDSETAL, LDSETL — 64-bit LDSETA</a>	FEAT_LSE	
11	0	1	0		0	100	<a href="#">LDSMAX, LDSMAXA, LDSMAXAL, LDSMAXL — 64-bit LDSMAXA</a>	FEAT_LSE	
11	0	1	0		0	101	<a href="#">LDSMIN, LDSMINA, LDSMINAL, LDSMINL — 64-bit LDSMINA</a>	FEAT_LSE	
11	0	1	0		0	110	<a href="#">LDUMAX, LDUMAXA, LDUMAXAL, LDUMAXL — 64-bit LDUMAXA</a>	FEAT_LSE	
11	0	1	0		0	111	<a href="#">LDUMIN, LDUMINA, LDUMINAL, LDUMINL — 64-bit LDUMINA</a>	FEAT_LSE	
11	0	1	0		1	000	<a href="#">SWP, SWPA, SWPAL, SWPL — 64-bit SWPA</a>	FEAT_LSE	
11	0	1	0		1	100	<a href="#">LDAPR — 64-bit</a>	FEAT_LRCPC	
11	0	1	1		0	000	<a href="#">LDADD, LDADDA, LDADDAL, LDADDL — 64-bit LDADDAL</a>	FEAT_LSE	
11	0	1	1		0	001	<a href="#">LDCLR, LDCLRA, LDCLRAL, LDCLRL — 64-bit LDCLRAL</a>	FEAT_LSE	
11	0	1	1		0	010	<a href="#">LDEOR, LDEORA, LDEORAL, LDEORL — 64-bit LDEORAL</a>	FEAT_LSE	
11	0	1	1		0	011	<a href="#">LDSET, LDSETA, LDSETAL, LDSETL — 64-bit LDSETAL</a>	FEAT_LSE	
11	0	1	1		0	100	<a href="#">LDSMAX, LDSMAXA, LDSMAXAL, LDSMAXL — 64-bit LDSMAXAL</a>	FEAT_LSE	
11	0	1	1		0	101	<a href="#">LDSMIN, LDSMINA, LDSMINAL, LDSMINL — 64-bit LDSMINAL</a>	FEAT_LSE	
11	0	1	1		0	110	<a href="#">LDUMAX, LDUMAXA, LDUMAXAL, LDUMAXL — 64-bit LDUMAXAL</a>	FEAT_LSE	
11	0	1	1		0	111	<a href="#">LDUMIN, LDUMINA, LDUMINAL, LDUMINL — 64-bit LDUMINAL</a>	FEAT_LSE	
11	0	1	1		1	000	<a href="#">SWP, SWPA, SWPAL, SWPL — 64-bit SWPAL</a>	FEAT_LSE	

**Load/store register (register offset)**

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size	1	1	1	V	0	0	opc	1			Rm			option	S	1	0			Rn									Rt		

Decode fields				Instruction Details
size	V	opc	option	
x1	1	1x		UNALLOCATED
00	0	00	!= 011	<a href="#">STRB (register) — extended register</a>
00	0	00	011	<a href="#">STRB (register) — shifted register</a>
00	0	01	!= 011	<a href="#">LDRB (register) — extended register</a>
00	0	01	011	<a href="#">LDRB (register) — shifted register</a>
00	0	10	!= 011	<a href="#">LDRSB (register) — 64-bit with extended register offset</a>
00	0	10	011	<a href="#">LDRSB (register) — 64-bit with shifted register offset</a>
00	0	11	!= 011	<a href="#">LDRSB (register) — 32-bit with extended register offset</a>
00	0	11	011	<a href="#">LDRSB (register) — 32-bit with shifted register offset</a>
00	1	00	!= 011	<a href="#">STR (register, SIMD&amp;FP)</a>
00	1	00	011	<a href="#">STR (register, SIMD&amp;FP)</a>
00	1	01	!= 011	<a href="#">LDR (register, SIMD&amp;FP)</a>
00	1	01	011	<a href="#">LDR (register, SIMD&amp;FP)</a>
00	1	10		<a href="#">STR (register, SIMD&amp;FP)</a>
00	1	11		<a href="#">LDR (register, SIMD&amp;FP)</a>
01	0	00		<a href="#">STRH (register)</a>
01	0	01		<a href="#">LDRH (register)</a>
01	0	10		<a href="#">LDRSH (register) — 64-bit</a>
01	0	11		<a href="#">LDRSH (register) — 32-bit</a>
01	1	00		<a href="#">STR (register, SIMD&amp;FP)</a>
01	1	01		<a href="#">LDR (register, SIMD&amp;FP)</a>
1x	0	11		UNALLOCATED
1x	1	1x		UNALLOCATED
10	0	00		<a href="#">STR (register) — 32-bit</a>
10	0	01		<a href="#">LDR (register) — 32-bit</a>
10	0	10		<a href="#">LDRSW (register)</a>
10	1	00		<a href="#">STR (register, SIMD&amp;FP)</a>
10	1	01		<a href="#">LDR (register, SIMD&amp;FP)</a>
11	0	00		<a href="#">STR (register) — 64-bit</a>
11	0	01		<a href="#">LDR (register) — 64-bit</a>
11	0	10		<a href="#">PRFM (register)</a>
11	1	00		<a href="#">STR (register, SIMD&amp;FP)</a>
11	1	01		<a href="#">LDR (register, SIMD&amp;FP)</a>

**Load/store register (pac)**

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size	1	1	1	V	0	0	M	S	1						imm9					W	1								Rn		Rt

Decode fields				Instruction Details	Feature
size	V	M	W		
!= 11				UNALLOCATED	-
11	0	0	0	<a href="#">LDRAA, LDRAB — key A, offset</a>	FEAT_PAuth
11	0	0	1	<a href="#">LDRAA, LDRAB — key A, pre-indexed</a>	FEAT_PAuth
11	0	1	0	<a href="#">LDRAA, LDRAB — key B, offset</a>	FEAT_PAuth

Decode fields				Instruction Details	Feature
size	V	M	W		
11	0	1	1	<a href="#">LDRAA, LDRAB</a> — <a href="#">key B, pre-indexed</a>	FEAT_PAuth
11	1			UNALLOCATED	-

### Load/store register (unsigned immediate)

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size	1	1	1	V	0	1	opc	imm12														Rn				Rt					

Decode fields			Instruction Details
size	V	opc	
x1	1	1x	UNALLOCATED
00	0	00	<a href="#">STRB (immediate)</a>
00	0	01	<a href="#">LDRB (immediate)</a>
00	0	10	<a href="#">LDRSB (immediate)</a> — 64-bit
00	0	11	<a href="#">LDRSB (immediate)</a> — 32-bit
00	1	00	<a href="#">STR (immediate, SIMD&amp;FP)</a> — 8-bit
00	1	01	<a href="#">LDR (immediate, SIMD&amp;FP)</a> — 8-bit
00	1	10	<a href="#">STR (immediate, SIMD&amp;FP)</a> — 128-bit
00	1	11	<a href="#">LDR (immediate, SIMD&amp;FP)</a> — 128-bit
01	0	00	<a href="#">STRH (immediate)</a>
01	0	01	<a href="#">LDRH (immediate)</a>
01	0	10	<a href="#">LDRSH (immediate)</a> — 64-bit
01	0	11	<a href="#">LDRSH (immediate)</a> — 32-bit
01	1	00	<a href="#">STR (immediate, SIMD&amp;FP)</a> — 16-bit
01	1	01	<a href="#">LDR (immediate, SIMD&amp;FP)</a> — 16-bit
1x	0	11	UNALLOCATED
1x	1	1x	UNALLOCATED
10	0	00	<a href="#">STR (immediate)</a> — 32-bit
10	0	01	<a href="#">LDR (immediate)</a> — 32-bit
10	0	10	<a href="#">LDRSW (immediate)</a>
10	1	00	<a href="#">STR (immediate, SIMD&amp;FP)</a> — 32-bit
10	1	01	<a href="#">LDR (immediate, SIMD&amp;FP)</a> — 32-bit
11	0	00	<a href="#">STR (immediate)</a> — 64-bit
11	0	01	<a href="#">LDR (immediate)</a> — 64-bit
11	0	10	<a href="#">PRFM (immediate)</a>
11	1	00	<a href="#">STR (immediate, SIMD&amp;FP)</a> — 64-bit
11	1	01	<a href="#">LDR (immediate, SIMD&amp;FP)</a> — 64-bit

### Data Processing -- Register

These instructions are under the [top-level](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
op0		op1		101		op2		op3																							

Decode fields				Instruction details
op0	op1	op2	op3	
0	1	0110		<a href="#">Data-processing (2 source)</a>

1	1	0110		<a href="#">Data-processing (1 source)</a>
	0	0xxx		<a href="#">Logical (shifted register)</a>
	0	1xx0		<a href="#">Add/subtract (shifted register)</a>
	0	1xx1		<a href="#">Add/subtract (extended register)</a>
	1	0000	000000	<a href="#">Add/subtract (with carry)</a>
	1	0000	x00001	<a href="#">Rotate right into flags</a>
	1	0000	xx0010	<a href="#">Evaluate into flags</a>
	1	0010	xxxx0x	<a href="#">Conditional compare (register)</a>
	1	0010	xxxx1x	<a href="#">Conditional compare (immediate)</a>
	1	0100		<a href="#">Conditional select</a>
	1	1xxx		<a href="#">Data-processing (3 source)</a>

### Data-processing (2 source)

These instructions are under [Data Processing -- Register](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	S	1	1	0	1	0	1	1	0	Rm					opcode					Rn					Rd					

Decode fields			Instruction Details		Feature
sf	S	opcode			
		000001	UNALLOCATED		-
		011xxx	UNALLOCATED		-
		1xxxxxx	UNALLOCATED		-
	0	00011x	UNALLOCATED		-
	0	001101	UNALLOCATED		-
	0	00111x	UNALLOCATED		-
	1	00001x	UNALLOCATED		-
	1	0001xx	UNALLOCATED		-
	1	001xxx	UNALLOCATED		-
	1	01xxxx	UNALLOCATED		-
0		000000	UNALLOCATED		-
0	0	000010	<a href="#">UDIV</a> — 32-bit		-
0	0	000011	<a href="#">SDIV</a> — 32-bit		-
0	0	00010x	UNALLOCATED		-
0	0	001000	<a href="#">LSLV</a> — 32-bit		-
0	0	001001	<a href="#">LSRV</a> — 32-bit		-
0	0	001010	<a href="#">ASRV</a> — 32-bit		-
0	0	001011	<a href="#">RORV</a> — 32-bit		-
0	0	001100	UNALLOCATED		-
0	0	010x11	UNALLOCATED		-
0	0	010000	<a href="#">CRC32B, CRC32H, CRC32W, CRC32X</a> — <a href="#">CRC32B</a>		-
0	0	010001	<a href="#">CRC32B, CRC32H, CRC32W, CRC32X</a> — <a href="#">CRC32H</a>		-
0	0	010010	<a href="#">CRC32B, CRC32H, CRC32W, CRC32X</a> — <a href="#">CRC32W</a>		-
0	0	010100	<a href="#">CRC32CB, CRC32CH, CRC32CW, CRC32CX</a> — <a href="#">CRC32CB</a>		-
0	0	010101	<a href="#">CRC32CB, CRC32CH, CRC32CW, CRC32CX</a> — <a href="#">CRC32CH</a>		-
0	0	010110	<a href="#">CRC32CB, CRC32CH, CRC32CW, CRC32CX</a> — <a href="#">CRC32CW</a>		-
1	0	000000	<a href="#">SUBP</a>		FEAT_MTE
1	0	000010	<a href="#">UDIV</a> — 64-bit		-
1	0	000011	<a href="#">SDIV</a> — 64-bit		-

Decode fields			Instruction Details	Feature
sf	S	opcode		
1	0	000100	<a href="#">IRG</a>	FEAT_MTE
1	0	000101	<a href="#">GMI</a>	FEAT_MTE
1	0	001000	<a href="#">LSLV — 64-bit</a>	-
1	0	001001	<a href="#">LSRV — 64-bit</a>	-
1	0	001010	<a href="#">ASRV — 64-bit</a>	-
1	0	001011	<a href="#">RORV — 64-bit</a>	-
1	0	001100	<a href="#">PACGA</a>	FEAT_PAuth
1	0	010xx0	UNALLOCATED	-
1	0	010x0x	UNALLOCATED	-
1	0	010011	<a href="#">CRC32B, CRC32H, CRC32W, CRC32X — CRC32X</a>	-
1	0	010111	<a href="#">CRC32CB, CRC32CH, CRC32CW, CRC32CX — CRC32CX</a>	-
1	1	000000	<a href="#">SUBPS</a>	FEAT_MTE

**Data-processing (1 source)**

These instructions are under [Data Processing -- Register](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	1	S	1	1	0	1	0	1	1	0	opcode2				opcode				Rn				Rd								

Decode fields				Rn	Instruction Details	Feature
sf	S	opcode2	opcode			
			1xxxxx		UNALLOCATED	-
		xxx1x			UNALLOCATED	-
		xx1xx			UNALLOCATED	-
		x1xxx			UNALLOCATED	-
		1xxxx			UNALLOCATED	-
	0	00000	00011x		UNALLOCATED	-
	0	00000	001xxx		UNALLOCATED	-
	0	00000	01xxxx		UNALLOCATED	-
	1				UNALLOCATED	-
0		00001			UNALLOCATED	-
0	0	00000	000000		<a href="#">RBIT — 32-bit</a>	-
0	0	00000	000001		<a href="#">REV16 — 32-bit</a>	-
0	0	00000	000010		<a href="#">REV — 32-bit</a>	-
0	0	00000	000011		UNALLOCATED	-
0	0	00000	000100		<a href="#">CLZ — 32-bit</a>	-
0	0	00000	000101		<a href="#">CLS — 32-bit</a>	-
1	0	00000	000000		<a href="#">RBIT — 64-bit</a>	-
1	0	00000	000001		<a href="#">REV16 — 64-bit</a>	-
1	0	00000	000010		<a href="#">REV32</a>	-
1	0	00000	000011		<a href="#">REV — 64-bit</a>	-
1	0	00000	000100		<a href="#">CLZ — 64-bit</a>	-
1	0	00000	000101		<a href="#">CLS — 64-bit</a>	-
1	0	00001	000000		<a href="#">PACIA, PACIA1716, PACIASP, PACIAZ, PACIZA — PACIA</a>	FEAT_PAuth
1	0	00001	000001		<a href="#">PACIB, PACIB1716, PACIBSP, PACIBZ, PACIZB — PACIB</a>	FEAT_PAuth
1	0	00001	000010		<a href="#">PACDA, PACDZA — PACDA</a>	FEAT_PAuth

sf	S	Decode fields		Rn	Instruction Details	Feature
		opcode2	opcode			
1	0	00001	000011		<a href="#">PACDB, PACDZB — PACDB</a>	FEAT_PAuth
1	0	00001	000100		<a href="#">AUTIA, AUTIA1716, AUTIASP, AUTIAZ, AUTIZA — AUTIA</a>	FEAT_PAuth
1	0	00001	000101		<a href="#">AUTIB, AUTIB1716, AUTIBSP, AUTIBZ, AUTIZB — AUTIB</a>	FEAT_PAuth
1	0	00001	000110		<a href="#">AUTDA, AUTDZA — AUTDA</a>	FEAT_PAuth
1	0	00001	000111		<a href="#">AUTDB, AUTDZB — AUTDB</a>	FEAT_PAuth
1	0	00001	001000	11111	<a href="#">PACIA, PACIA1716, PACIASP, PACIAZ, PACIZA — PACIZA</a>	FEAT_PAuth
1	0	00001	001001	11111	<a href="#">PACIB, PACIB1716, PACIBSP, PACIBZ, PACIZB — PACIZB</a>	FEAT_PAuth
1	0	00001	001010	11111	<a href="#">PACDA, PACDZA — PACDZA</a>	FEAT_PAuth
1	0	00001	001011	11111	<a href="#">PACDB, PACDZB — PACDZB</a>	FEAT_PAuth
1	0	00001	001100	11111	<a href="#">AUTIA, AUTIA1716, AUTIASP, AUTIAZ, AUTIZA — AUTIZA</a>	FEAT_PAuth
1	0	00001	001101	11111	<a href="#">AUTIB, AUTIB1716, AUTIBSP, AUTIBZ, AUTIZB — AUTIZB</a>	FEAT_PAuth
1	0	00001	001110	11111	<a href="#">AUTDA, AUTDZA — AUTDZA</a>	FEAT_PAuth
1	0	00001	001111	11111	<a href="#">AUTDB, AUTDZB — AUTDZB</a>	FEAT_PAuth
1	0	00001	010000	11111	<a href="#">XPACD, XPACL, XPACLRI — XPACI</a>	FEAT_PAuth
1	0	00001	010001	11111	<a href="#">XPACD, XPACL, XPACLRI — XPACD</a>	FEAT_PAuth
1	0	00001	01001x		UNALLOCATED	-
1	0	00001	0101xx		UNALLOCATED	-
1	0	00001	011xxx		UNALLOCATED	-

### Logical (shifted register)

These instructions are under [Data Processing -- Register](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	opc	0	1	0	1	0	shift	N	Rm				imm6				Rn				Rd										

sf	Decode fields			Instruction Details
	opc	N	imm6	
0			1xxxxx	UNALLOCATED
0	00	0		<a href="#">AND (shifted register) — 32-bit</a>
0	00	1		<a href="#">BIC (shifted register) — 32-bit</a>
0	01	0		<a href="#">ORR (shifted register) — 32-bit</a>
0	01	1		<a href="#">ORN (shifted register) — 32-bit</a>
0	10	0		<a href="#">EOR (shifted register) — 32-bit</a>
0	10	1		<a href="#">EON (shifted register) — 32-bit</a>
0	11	0		<a href="#">ANDS (shifted register) — 32-bit</a>
0	11	1		<a href="#">BICS (shifted register) — 32-bit</a>
1	00	0		<a href="#">AND (shifted register) — 64-bit</a>
1	00	1		<a href="#">BIC (shifted register) — 64-bit</a>
1	01	0		<a href="#">ORR (shifted register) — 64-bit</a>
1	01	1		<a href="#">ORN (shifted register) — 64-bit</a>
1	10	0		<a href="#">EOR (shifted register) — 64-bit</a>
1	10	1		<a href="#">EON (shifted register) — 64-bit</a>
1	11	0		<a href="#">ANDS (shifted register) — 64-bit</a>
1	11	1		<a href="#">BICS (shifted register) — 64-bit</a>



**Add/subtract (shifted register)**

These instructions are under [Data Processing -- Register](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	op	S	0	1	0	1	1	shift	0																						
										Rm						imm6						Rn						Rd			

Decode fields					Instruction Details	
sf	op	S	shift	imm6		
			11		UNALLOCATED	
0				1xxxxx	UNALLOCATED	
0	0	0			<a href="#">ADD (shifted register) — 32-bit</a>	
0	0	1			<a href="#">ADDS (shifted register) — 32-bit</a>	
0	1	0			<a href="#">SUB (shifted register) — 32-bit</a>	
0	1	1			<a href="#">SUBS (shifted register) — 32-bit</a>	
1	0	0			<a href="#">ADD (shifted register) — 64-bit</a>	
1	0	1			<a href="#">ADDS (shifted register) — 64-bit</a>	
1	1	0			<a href="#">SUB (shifted register) — 64-bit</a>	
1	1	1			<a href="#">SUBS (shifted register) — 64-bit</a>	

**Add/subtract (extended register)**

These instructions are under [Data Processing -- Register](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	op	S	0	1	0	1	1	opt	1																						
										Rm						option		imm3				Rn						Rd			

Decode fields					Instruction Details	
sf	op	S	opt	imm3		
				1x1	UNALLOCATED	
				11x	UNALLOCATED	
			x1		UNALLOCATED	
			1x		UNALLOCATED	
0	0	0	00		<a href="#">ADD (extended register) — 32-bit</a>	
0	0	1	00		<a href="#">ADDS (extended register) — 32-bit</a>	
0	1	0	00		<a href="#">SUB (extended register) — 32-bit</a>	
0	1	1	00		<a href="#">SUBS (extended register) — 32-bit</a>	
1	0	0	00		<a href="#">ADD (extended register) — 64-bit</a>	
1	0	1	00		<a href="#">ADDS (extended register) — 64-bit</a>	
1	1	0	00		<a href="#">SUB (extended register) — 64-bit</a>	
1	1	1	00		<a href="#">SUBS (extended register) — 64-bit</a>	

**Add/subtract (with carry)**

These instructions are under [Data Processing -- Register](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	op	S	1	1	0	1	0	0	0	0																					
										Rm						0	0	0	0	0	0	Rn						Rd			

Decode fields			Instruction Details
sf	op	S	
0	0	0	<a href="#">ADC — 32-bit</a>
0	0	1	<a href="#">ADCS — 32-bit</a>
0	1	0	<a href="#">SBC — 32-bit</a>
0	1	1	<a href="#">SBCS — 32-bit</a>

Decode fields			Instruction Details
sf	op	S	
1	0	0	<a href="#">ADC — 64-bit</a>
1	0	1	<a href="#">ADCS — 64-bit</a>
1	1	0	<a href="#">SBC — 64-bit</a>
1	1	1	<a href="#">SBBCS — 64-bit</a>

## Rotate right into flags

These instructions are under [Data Processing -- Register](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	op	S	1	1	0	1	0	0	0	0	imm6				0	0	0	0	1	Rn				o2	mask						

Decode fields				Instruction Details	Feature
sf	op	S	o2		
0				UNALLOCATED	-
1	0	0		UNALLOCATED	-
1	0	1	0	<a href="#">RMIF</a>	FEAT_FlagM
1	0	1	1	UNALLOCATED	-
1	1			UNALLOCATED	-

## Evaluate into flags

These instructions are under [Data Processing -- Register](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0																
sf		op		S		1		1		0		1		0		0		0		0		opcode2						sz		0		0		1		0		Rn						o3		mask	

[illegible]

## Conditional compare (register)

These instructions are under [Data Processing -- Register](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	op	S	1	1	0	1	0	0	1	0	Rm				cond				0	o2	Rn				o3	nzcv					

Decode fields					Instruction Details
sf	op	S	o2	o3	
				1	UNALLOCATED
			1		UNALLOCATED
		0			UNALLOCATED
0	0	1	0	0	<a href="#">CCMN (register)</a> — 32-bit
0	1	1	0	0	<a href="#">CCMP (register)</a> — 32-bit

Decode fields					Instruction Details
sf	op	S	o2	o3	
1	0	1	0	0	<a href="#">CCMN (register) — 64-bit</a>
1	1	1	0	0	<a href="#">CCMP (register) — 64-bit</a>

### Conditional compare (immediate)

These instructions are under [Data Processing -- Register](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
sf	op	S	1	1	0	1	0	0	1	0	imm5					cond					1	o2	Rn					o3	nzcw				

Decode fields					Instruction Details
sf	op	S	o2	o3	
				1	UNALLOCATED
			1		UNALLOCATED
		0			UNALLOCATED
0	0	1	0	0	<a href="#">CCMN (immediate) — 32-bit</a>
0	1	1	0	0	<a href="#">CCMP (immediate) — 32-bit</a>
1	0	1	0	0	<a href="#">CCMN (immediate) — 64-bit</a>
1	1	1	0	0	<a href="#">CCMP (immediate) — 64-bit</a>

### Conditional select

These instructions are under [Data Processing -- Register](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	op	S	1	1	0	1	0	1	0	0	Rm					cond					op2	Rn					Rd				

Decode fields				Instruction Details
sf	op	S	op2	
			1x	UNALLOCATED
		1		UNALLOCATED
0	0	0	00	<a href="#">CSEL — 32-bit</a>
0	0	0	01	<a href="#">CSINC — 32-bit</a>
0	1	0	00	<a href="#">CSINV — 32-bit</a>
0	1	0	01	<a href="#">CSNEG — 32-bit</a>
1	0	0	00	<a href="#">CSEL — 64-bit</a>
1	0	0	01	<a href="#">CSINC — 64-bit</a>
1	1	0	00	<a href="#">CSINV — 64-bit</a>
1	1	0	01	<a href="#">CSNEG — 64-bit</a>

### Data-processing (3 source)

These instructions are under [Data Processing -- Register](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
sf	op54	1	1	0	1	1	op31					Rm					o0	Ra					Rn					Rd				

Decode fields				Instruction Details
sf	op54	op31	o0	
	00	010	1	UNALLOCATED
	00	011		UNALLOCATED
	00	100		UNALLOCATED

sf	Decode fields		o0	Instruction Details
	op54	op31		
	00	110	1	UNALLOCATED
	00	111		UNALLOCATED
	01			UNALLOCATED
	1x			UNALLOCATED
0	00	000	0	<a href="#">MADD — 32-bit</a>
0	00	000	1	<a href="#">MSUB — 32-bit</a>
0	00	001	0	UNALLOCATED
0	00	001	1	UNALLOCATED
0	00	010	0	UNALLOCATED
0	00	101	0	UNALLOCATED
0	00	101	1	UNALLOCATED
0	00	110	0	UNALLOCATED
1	00	000	0	<a href="#">MADD — 64-bit</a>
1	00	000	1	<a href="#">MSUB — 64-bit</a>
1	00	001	0	<a href="#">SMADDL</a>
1	00	001	1	<a href="#">SMSUBL</a>
1	00	010	0	<a href="#">SMULH</a>
1	00	101	0	<a href="#">UMADDL</a>
1	00	101	1	<a href="#">UMSUBL</a>
1	00	110	0	<a href="#">UMULH</a>

## Data Processing -- Scalar Floating-Point and Advanced SIMD

These instructions are under the [top-level](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
op0				111			op1		op2			op3																			

Decode fields				Instruction details	Architecture version
op0	op1	op2	op3		
0000	0x	x101	00xxxxx10	UNALLOCATED	-
0010	0x	x101	00xxxxx10	UNALLOCATED	-
0100	0x	x101	00xxxxx10	<a href="#">Cryptographic AES</a>	-
0101	0x	x0xx	xxx0xxx00	<a href="#">Cryptographic three-register SHA</a>	-
0101	0x	x0xx	xxx0xxx10	UNALLOCATED	-
0101	0x	x101	00xxxxx10	<a href="#">Cryptographic two-register SHA</a>	-
0110	0x	x101	00xxxxx10	UNALLOCATED	-
0111	0x	x0xx	xxx0xxxxx0	UNALLOCATED	-
0111	0x	x101	00xxxxx10	UNALLOCATED	-
01x1	00	00xx	xxx0xxxxx1	<a href="#">Advanced SIMD scalar copy</a>	-
01x1	01	00xx	xxx0xxxxx1	UNALLOCATED	-
01x1	0x	0111	00xxxxx10	UNALLOCATED	-
01x1	0x	10xx	xxx00xxx1	<a href="#">Advanced SIMD scalar three same FP16</a>	-
01x1	0x	10xx	xxx01xxx1	UNALLOCATED	-
01x1	0x	1111	00xxxxx10	<a href="#">Advanced SIMD scalar two-register miscellaneous FP16</a>	-
01x1	0x	x0xx	xxx1xxxxx0	UNALLOCATED	-
01x1	0x	x0xx	xxx1xxxxx1	<a href="#">Advanced SIMD scalar three same extra</a>	-

01x1	0x	x100	00xxxxx10	<a href="#">Advanced SIMD scalar two-register miscellaneous</a>	-
01x1	0x	x110	00xxxxx10	<a href="#">Advanced SIMD scalar pairwise</a>	-
01x1	0x	x1xx	1xxxxxx10	UNALLOCATED	-
01x1	0x	x1xx	x1xxxxx10	UNALLOCATED	-
01x1	0x	x1xx	xxxxxxx00	<a href="#">Advanced SIMD scalar three different</a>	-
01x1	0x	x1xx	xxxxxxx1	<a href="#">Advanced SIMD scalar three same</a>	-
01x1	10		xxxxxxx1	<a href="#">Advanced SIMD scalar shift by immediate</a>	-
01x1	11		xxxxxxx1	UNALLOCATED	-
01x1	1x		xxxxxxx0	<a href="#">Advanced SIMD scalar x indexed element</a>	-
0x00	0x	x0xx	xxx0xxx00	<a href="#">Advanced SIMD table lookup</a>	-
0x00	0x	x0xx	xxx0xxx10	<a href="#">Advanced SIMD permute</a>	-
0x10	0x	x0xx	xxx0xxxx0	<a href="#">Advanced SIMD extract</a>	-
0xx0	00	00xx	xxx0xxx1	<a href="#">Advanced SIMD copy</a>	-
0xx0	01	00xx	xxx0xxx1	UNALLOCATED	-
0xx0	0x	0111	00xxxxx10	UNALLOCATED	-
0xx0	0x	10xx	xxx00xxx1	<a href="#">Advanced SIMD three same (FP16)</a>	-
0xx0	0x	10xx	xxx01xxx1	UNALLOCATED	-
0xx0	0x	1111	00xxxxx10	<a href="#">Advanced SIMD two-register miscellaneous (FP16)</a>	-
0xx0	0x	x0xx	xxx1xxxx0	UNALLOCATED	-
0xx0	0x	x0xx	xxx1xxx1	<a href="#">Advanced SIMD three-register extension</a>	-
0xx0	0x	x100	00xxxxx10	<a href="#">Advanced SIMD two-register miscellaneous</a>	-
0xx0	0x	x110	00xxxxx10	<a href="#">Advanced SIMD across lanes</a>	-
0xx0	0x	x1xx	1xxxxxx10	UNALLOCATED	-
0xx0	0x	x1xx	x1xxxxx10	UNALLOCATED	-
0xx0	0x	x1xx	xxxxxxx00	<a href="#">Advanced SIMD three different</a>	-
0xx0	0x	x1xx	xxxxxxx1	<a href="#">Advanced SIMD three same</a>	-
0xx0	10	0000	xxxxxxx1	<a href="#">Advanced SIMD modified immediate</a>	-
0xx0	10	!= 0000	xxxxxxx1	<a href="#">Advanced SIMD shift by immediate</a>	-
0xx0	11		xxxxxxx1	UNALLOCATED	-
0xx0	1x		xxxxxxx0	<a href="#">Advanced SIMD vector x indexed element</a>	-
1100	00	10xx	xxx10xxxx	<a href="#">Cryptographic three-register, imm2</a>	-
1100	00	11xx	xxx1x00xx	<a href="#">Cryptographic three-register SHA 512</a>	-
1100	00		xxx0xxxxx	<a href="#">Cryptographic four-register</a>	-
1100	01	00xx		<a href="#">XAR</a>	FEAT_SHA3
1100	01	1000	0001000xx	<a href="#">Cryptographic two-register SHA 512</a>	-
1xx0	1x			UNALLOCATED	-
x0x1	0x	x0xx		<a href="#">Conversion between floating-point and fixed-point</a>	-
x0x1	0x	x1xx	xxx000000	<a href="#">Conversion between floating-point and integer</a>	-
x0x1	0x	x1xx	xxx10000	<a href="#">Floating-point data-processing (1 source)</a>	-
x0x1	0x	x1xx	xxxxx1000	<a href="#">Floating-point compare</a>	-
x0x1	0x	x1xx	xxxxxx100	<a href="#">Floating-point immediate</a>	-
x0x1	0x	x1xx	xxxxxxx01	<a href="#">Floating-point conditional compare</a>	-
x0x1	0x	x1xx	xxxxxxx10	<a href="#">Floating-point data-processing (2 source)</a>	-
x0x1	0x	x1xx	xxxxxxx11	<a href="#">Floating-point conditional select</a>	-
x0x1	1x			<a href="#">Floating-point data-processing (3 source)</a>	-

## Cryptographic AES

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	1	1	1	0	size	1	0	1	0	0	opcode				1	0	Rn				Rd							

Decode fields size	opcode	Instruction Details
	x1xxx	UNALLOCATED
	000xx	UNALLOCATED
	1xxxx	UNALLOCATED
x1		UNALLOCATED
00	00100	<a href="#">AESE</a>
00	00101	<a href="#">AESD</a>
00	00110	<a href="#">AESMC</a>
00	00111	<a href="#">AESIMC</a>
1x		UNALLOCATED

## Cryptographic three-register SHA

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	size	0	Rm				0	opcode				0	0	Rn				Rd						

Decode fields size	opcode	Instruction Details
	111	UNALLOCATED
x1		UNALLOCATED
00	000	<a href="#">SHA1C</a>
00	001	<a href="#">SHA1P</a>
00	010	<a href="#">SHA1M</a>
00	011	<a href="#">SHA1SU0</a>
00	100	<a href="#">SHA256H</a>
00	101	<a href="#">SHA256H2</a>
00	110	<a href="#">SHA256SU1</a>
1x		UNALLOCATED

## Cryptographic two-register SHA

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	size	1	0	1	0	0	opcode				1	0	Rn				Rd							

Decode fields size	opcode	Instruction Details
	xx1xx	UNALLOCATED
	x1xxx	UNALLOCATED
	1xxxx	UNALLOCATED
x1		UNALLOCATED
00	00000	<a href="#">SHA1H</a>
00	00001	<a href="#">SHA1SU1</a>
00	00010	<a href="#">SHA256SU0</a>

Decode fields size	opcode	Instruction Details
00	00011	UNALLOCATED
1x		UNALLOCATED

### Advanced SIMD scalar copy

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	op	1	1	1	1	0	0	0	0		imm5				0		imm4				1		Rn				Rd			

Decode fields op	imm4	Instruction Details
0	xxx1	UNALLOCATED
0	xx1x	UNALLOCATED
0	x1xx	UNALLOCATED
0	0000	<a href="#">DUP (element)</a>
0	1xxx	UNALLOCATED
1		UNALLOCATED

### Advanced SIMD scalar three same FP16

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	U	1	1	1	1	0	a	1	0		Rm				0	0	opcode				1		Rn				Rd			

Decode fields U	a	opcode	Instruction Details	Feature
		110	UNALLOCATED	-
	1	011	UNALLOCATED	-
0	0	011	<a href="#">FMULX</a>	FEAT_FP16
0	0	100	<a href="#">FCMEQ (register)</a>	FEAT_FP16
0	0	101	UNALLOCATED	-
0	0	111	<a href="#">FRECPS</a>	FEAT_FP16
0	1	100	UNALLOCATED	-
0	1	101	UNALLOCATED	-
0	1	111	<a href="#">FRSQRTS</a>	FEAT_FP16
1	0	011	UNALLOCATED	-
1	0	100	<a href="#">FCMGE (register)</a>	FEAT_FP16
1	0	101	<a href="#">FACGE</a>	FEAT_FP16
1	0	111	UNALLOCATED	-
1	1	010	<a href="#">FABD</a>	FEAT_FP16
1	1	100	<a href="#">FCMGT (register)</a>	FEAT_FP16
1	1	101	<a href="#">FACGT</a>	FEAT_FP16
1	1	111	UNALLOCATED	-

### Advanced SIMD scalar two-register miscellaneous FP16

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	U	1	1	1	1	0	a	1	1	1	1	0	0	opcode				1	0	Rn				Rd						

Decode fields			Instruction Details	Feature
U	a	opcode		
		00xxx	UNALLOCATED	-
		010xx	UNALLOCATED	-
		10xxx	UNALLOCATED	-
		1100x	UNALLOCATED	-
		11110	UNALLOCATED	-
	0	011xx	UNALLOCATED	-
	0	11111	UNALLOCATED	-
	1	01111	UNALLOCATED	-
	1	11100	UNALLOCATED	-
0	0	11010	<a href="#">FCVTNS (vector)</a>	FEAT_FP16
0	0	11011	<a href="#">FCVTMS (vector)</a>	FEAT_FP16
0	0	11100	<a href="#">FCVTAS (vector)</a>	FEAT_FP16
0	0	11101	<a href="#">SCVTF (vector, integer)</a>	FEAT_FP16
0	1	01100	<a href="#">FCMGT (zero)</a>	FEAT_FP16
0	1	01101	<a href="#">FCMEQ (zero)</a>	FEAT_FP16
0	1	01110	<a href="#">FCMLT (zero)</a>	FEAT_FP16
0	1	11010	<a href="#">FCVTPS (vector)</a>	FEAT_FP16
0	1	11011	<a href="#">FCVTZS (vector, integer)</a>	FEAT_FP16
0	1	11101	<a href="#">FRECPE</a>	FEAT_FP16
0	1	11111	<a href="#">FRECPX</a>	FEAT_FP16
1	0	11010	<a href="#">FCVTNU (vector)</a>	FEAT_FP16
1	0	11011	<a href="#">FCVTMU (vector)</a>	FEAT_FP16
1	0	11100	<a href="#">FCVTAU (vector)</a>	FEAT_FP16
1	0	11101	<a href="#">UCVTF (vector, integer)</a>	FEAT_FP16
1	1	01100	<a href="#">FCMGE (zero)</a>	FEAT_FP16
1	1	01101	<a href="#">FCMLE (zero)</a>	FEAT_FP16
1	1	01110	UNALLOCATED	-
1	1	11010	<a href="#">FCVTPU (vector)</a>	FEAT_FP16
1	1	11011	<a href="#">FCVTZU (vector, integer)</a>	FEAT_FP16
1	1	11101	<a href="#">FRSQRT</a>	FEAT_FP16
1	1	11111	UNALLOCATED	-

### Advanced SIMD scalar three same extra

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	U	1	1	1	1	0	size	0	Rm			1	opcode			1	Rn			Rd										

Decode fields		Instruction Details	Feature
U	opcode		
	001x	UNALLOCATED	-
	01xx	UNALLOCATED	-
	1xxx	UNALLOCATED	-
0	0000	UNALLOCATED	-
0	0001	UNALLOCATED	-
1	0000	<a href="#">SQRDMLAH (vector)</a>	FEAT_RDM
1	0001	<a href="#">SQRDMLSH (vector)</a>	FEAT_RDM



**Advanced SIMD scalar two-register miscellaneous**

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	U	1	1	1	1	0	size	1	0	0	0	0	0	opcode				1	0	Rn				Rd						

Decode fields			Instruction Details
U	size	opcode	
		0000x	UNALLOCATED
		00010	UNALLOCATED
		0010x	UNALLOCATED
		00110	UNALLOCATED
		01111	UNALLOCATED
		1000x	UNALLOCATED
		10011	UNALLOCATED
		10101	UNALLOCATED
		10111	UNALLOCATED
		1100x	UNALLOCATED
		11110	UNALLOCATED
	0x	011xx	UNALLOCATED
	0x	11111	UNALLOCATED
	1x	10110	UNALLOCATED
	1x	11100	UNALLOCATED
0		00011	<a href="#">SUQADD</a>
0		00111	<a href="#">SQABS</a>
0		01000	<a href="#">CMGT (zero)</a>
0		01001	<a href="#">CMEQ (zero)</a>
0		01010	<a href="#">CMLT (zero)</a>
0		01011	<a href="#">ABS</a>
0		10010	UNALLOCATED
0		10100	<a href="#">SQXTN, SQXTN2</a>
0	0x	10110	UNALLOCATED
0	0x	11010	<a href="#">FCVTNS (vector)</a>
0	0x	11011	<a href="#">FCVTMS (vector)</a>
0	0x	11100	<a href="#">FCVTAS (vector)</a>
0	0x	11101	<a href="#">SCVTF (vector, integer)</a>
0	1x	01100	<a href="#">FCMGT (zero)</a>
0	1x	01101	<a href="#">FCMEQ (zero)</a>
0	1x	01110	<a href="#">FCMLT (zero)</a>
0	1x	11010	<a href="#">FCVTPS (vector)</a>
0	1x	11011	<a href="#">FCVTZS (vector, integer)</a>
0	1x	11101	<a href="#">FRECPE</a>
0	1x	11111	<a href="#">FRECPX</a>
1		00011	<a href="#">USQADD</a>
1		00111	<a href="#">SQNEG</a>
1		01000	<a href="#">CMGE (zero)</a>
1		01001	<a href="#">CMLE (zero)</a>
1		01010	UNALLOCATED
1		01011	<a href="#">NEG (vector)</a>
1		10010	<a href="#">SQXTUN, SQXTUN2</a>

Decode fields			Instruction Details
U	size	opcode	
1		10100	<a href="#">UQXTN, UQXTN2</a>
1	0x	10110	<a href="#">FCVTXN, FCVTXN2</a>
1	0x	11010	<a href="#">FCVTNU (vector)</a>
1	0x	11011	<a href="#">FCVTMU (vector)</a>
1	0x	11100	<a href="#">FCVTAU (vector)</a>
1	0x	11101	<a href="#">UCVTF (vector, integer)</a>
1	1x	01100	<a href="#">FCMGE (zero)</a>
1	1x	01101	<a href="#">FCMLE (zero)</a>
1	1x	01110	UNALLOCATED
1	1x	11010	<a href="#">FCVTPU (vector)</a>
1	1x	11011	<a href="#">FCVTZU (vector, integer)</a>
1	1x	11101	<a href="#">FRSQRT</a>
1	1x	11111	UNALLOCATED

### Advanced SIMD scalar pairwise

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	U	1	1	1	1	0	size	1	1	0	0	0	opcode				1	0	Rn				Rd							

Decode fields			Instruction Details	Feature
U	size	opcode		
		00xxx	UNALLOCATED	-
		010xx	UNALLOCATED	-
		01110	UNALLOCATED	-
		10xxx	UNALLOCATED	-
		1100x	UNALLOCATED	-
		11010	UNALLOCATED	-
		111xx	UNALLOCATED	-
	1x	01101	UNALLOCATED	-
0		11011	<a href="#">ADDP (scalar)</a>	-
0	0x	01100	<a href="#">FMAXNMP (scalar) — half-precision</a>	FEAT_FP16
0	0x	01101	<a href="#">FADDP (scalar) — half-precision</a>	FEAT_FP16
0	0x	01111	<a href="#">FMAXP (scalar) — half-precision</a>	FEAT_FP16
0	1x	01100	<a href="#">FMINNMP (scalar) — half-precision</a>	FEAT_FP16
0	1x	01111	<a href="#">FMINP (scalar) — half-precision</a>	FEAT_FP16
1		11011	UNALLOCATED	-
1	0x	01100	<a href="#">FMAXNMP (scalar) — single-precision and double-precision</a>	-
1	0x	01101	<a href="#">FADDP (scalar) — single-precision and double-precision</a>	-
1	0x	01111	<a href="#">FMAXP (scalar) — single-precision and double-precision</a>	-
1	1x	01100	<a href="#">FMINNMP (scalar) — single-precision and double-precision</a>	-
1	1x	01111	<a href="#">FMINP (scalar) — single-precision and double-precision</a>	-

### Advanced SIMD scalar three different

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	U	1	1	1	1	0	size	1	Rm				opcode				0	0	Rn				Rd							

Decode fields		Instruction Details
U	opcode	
	00xx	UNALLOCATED
	01xx	UNALLOCATED
	1000	UNALLOCATED
	1010	UNALLOCATED
	1100	UNALLOCATED
	111x	UNALLOCATED
0	1001	<a href="#">SQDMLAL, SQDMLAL2 (vector)</a>
0	1011	<a href="#">SQDMLSL, SQDMLSL2 (vector)</a>
0	1101	<a href="#">SQDMULL, SQDMULL2 (vector)</a>
1	1001	UNALLOCATED
1	1011	UNALLOCATED
1	1101	UNALLOCATED

### Advanced SIMD scalar three same

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	U	1	1	1	1	0	size	1	Rm			opcode			1	Rn			Rd											

Decode fields			Instruction Details
U	size	opcode	
		00000	UNALLOCATED
		0001x	UNALLOCATED
		00100	UNALLOCATED
		011xx	UNALLOCATED
		1001x	UNALLOCATED
	1x	11011	UNALLOCATED
0		00001	<a href="#">SQADD</a>
0		00101	<a href="#">SQSUB</a>
0		00110	<a href="#">CMGT (register)</a>
0		00111	<a href="#">CMGE (register)</a>
0		01000	<a href="#">SSHL</a>
0		01001	<a href="#">SQSHL (register)</a>
0		01010	<a href="#">SRSHL</a>
0		01011	<a href="#">SQRSHL</a>
0		10000	<a href="#">ADD (vector)</a>
0		10001	<a href="#">CMTST</a>
0		10100	UNALLOCATED
0		10101	UNALLOCATED
0		10110	<a href="#">SQDMULH (vector)</a>
0		10111	UNALLOCATED
0	0x	11000	UNALLOCATED
0	0x	11001	UNALLOCATED
0	0x	11010	UNALLOCATED
0	0x	11011	<a href="#">FMULX</a>
0	0x	11100	<a href="#">FCMEQ (register)</a>
0	0x	11101	UNALLOCATED
0	0x	11110	UNALLOCATED

U	Decode fields		Instruction Details
	size	opcode	
0	0x	11111	<a href="#">FRECPS</a>
0	1x	11000	UNALLOCATED
0	1x	11001	UNALLOCATED
0	1x	11010	UNALLOCATED
0	1x	11100	UNALLOCATED
0	1x	11101	UNALLOCATED
0	1x	11110	UNALLOCATED
0	1x	11111	<a href="#">FRSQRTS</a>
1		00001	<a href="#">UQADD</a>
1		00101	<a href="#">UQSUB</a>
1		00110	<a href="#">CMHI (register)</a>
1		00111	<a href="#">CMHS (register)</a>
1		01000	<a href="#">USHL</a>
1		01001	<a href="#">UQSHL (register)</a>
1		01010	<a href="#">URSHL</a>
1		01011	<a href="#">UQRSHL</a>
1		10000	<a href="#">SUB (vector)</a>
1		10001	<a href="#">CMEQ (register)</a>
1		10100	UNALLOCATED
1		10101	UNALLOCATED
1		10110	<a href="#">SQRDMULH (vector)</a>
1		10111	UNALLOCATED
1	0x	11000	UNALLOCATED
1	0x	11001	UNALLOCATED
1	0x	11010	UNALLOCATED
1	0x	11011	UNALLOCATED
1	0x	11100	<a href="#">FCMGE (register)</a>
1	0x	11101	<a href="#">FACGE</a>
1	0x	11110	UNALLOCATED
1	0x	11111	UNALLOCATED
1	1x	11000	UNALLOCATED
1	1x	11001	UNALLOCATED
1	1x	11010	<a href="#">FABD</a>
1	1x	11100	<a href="#">FCMGT (register)</a>
1	1x	11101	<a href="#">FACGT</a>
1	1x	11110	UNALLOCATED
1	1x	11111	UNALLOCATED

### Advanced SIMD scalar shift by immediate

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	U	1	1	1	1	1	0	immh				immb			opcode					1	Rn				Rd					

U	Decode fields		Instruction Details
	immh	opcode	
	!= 0000	00001	UNALLOCATED
	!= 0000	00011	UNALLOCATED

U	Decode fields		Instruction Details
	immh	opcode	
	!= 0000	00101	UNALLOCATED
	!= 0000	00111	UNALLOCATED
	!= 0000	01001	UNALLOCATED
	!= 0000	01011	UNALLOCATED
	!= 0000	01101	UNALLOCATED
	!= 0000	01111	UNALLOCATED
	!= 0000	101xx	UNALLOCATED
	!= 0000	110xx	UNALLOCATED
	!= 0000	11101	UNALLOCATED
	!= 0000	11110	UNALLOCATED
	0000		UNALLOCATED
0	!= 0000	00000	<a href="#">SSHR</a>
0	!= 0000	00010	<a href="#">SSRA</a>
0	!= 0000	00100	<a href="#">SRSHR</a>
0	!= 0000	00110	<a href="#">SRSRA</a>
0	!= 0000	01000	UNALLOCATED
0	!= 0000	01010	<a href="#">SHL</a>
0	!= 0000	01100	UNALLOCATED
0	!= 0000	01110	<a href="#">SQSHL (immediate)</a>
0	!= 0000	10000	UNALLOCATED
0	!= 0000	10001	UNALLOCATED
0	!= 0000	10010	<a href="#">SQSHRN, SQSHRN2</a>
0	!= 0000	10011	<a href="#">SQRSHRN, SQRSHRN2</a>
0	!= 0000	11100	<a href="#">SCVTF (vector, fixed-point)</a>
0	!= 0000	11111	<a href="#">FCVTZS (vector, fixed-point)</a>
1	!= 0000	00000	<a href="#">USHR</a>
1	!= 0000	00010	<a href="#">USRA</a>
1	!= 0000	00100	<a href="#">URSHR</a>
1	!= 0000	00110	<a href="#">URSRA</a>
1	!= 0000	01000	<a href="#">SRI</a>
1	!= 0000	01010	<a href="#">SLI</a>
1	!= 0000	01100	<a href="#">SQSHLU</a>
1	!= 0000	01110	<a href="#">UQSHL (immediate)</a>
1	!= 0000	10000	<a href="#">SQSHRUN, SQSHRUN2</a>
1	!= 0000	10001	<a href="#">SQRSHRUN, SQRSHRUN2</a>
1	!= 0000	10010	<a href="#">UQSHRN, UQSHRN2</a>
1	!= 0000	10011	<a href="#">UQRSHRN, UQRSHRN2</a>
1	!= 0000	11100	<a href="#">UCVTF (vector, fixed-point)</a>
1	!= 0000	11111	<a href="#">FCVTZU (vector, fixed-point)</a>

### Advanced SIMD scalar x indexed element

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	U	1	1	1	1	1	size	L	M			Rm				opcode	H	0					Rn					Rd		

Decode fields			Instruction Details	Feature
U	size	opcode		
		0000	UNALLOCATED	-
		0010	UNALLOCATED	-
		0100	UNALLOCATED	-
		0110	UNALLOCATED	-
		1000	UNALLOCATED	-
		1010	UNALLOCATED	-
		1110	UNALLOCATED	-
	01	0001	UNALLOCATED	-
	01	0101	UNALLOCATED	-
	01	1001	UNALLOCATED	-
0		0011	<a href="#">SQDMLAL, SQDMLAL2 (by element)</a>	-
0		0111	<a href="#">SQDMLSL, SQDMLSL2 (by element)</a>	-
0		1011	<a href="#">SQDMULL, SQDMULL2 (by element)</a>	-
0		1100	<a href="#">SQDMULH (by element)</a>	-
0		1101	<a href="#">SQRDMULH (by element)</a>	-
0		1111	UNALLOCATED	-
0	00	0001	<a href="#">FMLA (by element) — half-precision</a>	FEAT_FP16
0	00	0101	<a href="#">FMLS (by element) — half-precision</a>	FEAT_FP16
0	00	1001	<a href="#">FMUL (by element) — half-precision</a>	FEAT_FP16
0	1x	0001	<a href="#">FMLA (by element) — single-precision and double-precision</a>	-
0	1x	0101	<a href="#">FMLS (by element) — single-precision and double-precision</a>	-
0	1x	1001	<a href="#">FMUL (by element) — single-precision and double-precision</a>	-
1		0011	UNALLOCATED	-
1		0111	UNALLOCATED	-
1		1011	UNALLOCATED	-
1		1100	UNALLOCATED	-
1		1101	<a href="#">SQRDMLAH (by element)</a>	FEAT_RDM
1		1111	<a href="#">SQRDMLSH (by element)</a>	FEAT_RDM
1	00	0001	UNALLOCATED	-
1	00	0101	UNALLOCATED	-
1	00	1001	<a href="#">FMULX (by element) — half-precision</a>	FEAT_FP16
1	1x	0001	UNALLOCATED	-
1	1x	0101	UNALLOCATED	-
1	1x	1001	<a href="#">FMULX (by element) — single-precision and double-precision</a>	-

### Advanced SIMD table lookup

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	op2	0	Rm				0	len	op	0	0	Rn				Rd								

Decode fields			Instruction Details
op2	len	op	
x1			UNALLOCATED
00	00	0	<a href="#">TBL — single register table</a>
00	00	1	<a href="#">TBX — single register table</a>
00	01	0	<a href="#">TBL — two register table</a>
00	01	1	<a href="#">TBX — two register table</a>

Decode fields			Instruction Details
op2	len	op	
00	10	0	<a href="#">TBL — three register table</a>
00	10	1	<a href="#">TBX — three register table</a>
00	11	0	<a href="#">TBL — four register table</a>
00	11	1	<a href="#">TBX — four register table</a>
1x			UNALLOCATED

### Advanced SIMD permute

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	size	0		Rm		0	opcode	1	0		Rn													

Decode fields opcode	Instruction Details
000	UNALLOCATED
001	<a href="#">UZP1</a>
010	<a href="#">TRN1</a>
011	<a href="#">ZIP1</a>
100	UNALLOCATED
101	<a href="#">UZP2</a>
110	<a href="#">TRN2</a>
111	<a href="#">ZIP2</a>

### Advanced SIMD extract

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	op2	0		Rm		0	imm4	0		Rn														

Decode fields op2	Instruction Details
x1	UNALLOCATED
00	<a href="#">EXT</a>
1x	UNALLOCATED

### Advanced SIMD copy

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	op	0	1	1	1	0	0	0	0		imm5		0	imm4	1		Rn													

Q	op	Decode fields imm5	imm4	Instruction Details
		x0000		UNALLOCATED
	0		0000	<a href="#">DUP (element)</a>
	0		0001	<a href="#">DUP (general)</a>
	0		0010	UNALLOCATED
	0		0100	UNALLOCATED
	0		0110	UNALLOCATED

Decode fields				Instruction Details
Q	op	imm5	imm4	
	0		1xxx	UNALLOCATED
0	0		0011	UNALLOCATED
0	0		0101	<a href="#">SMOV</a>
0	0		0111	<a href="#">UMOV</a>
0	1			UNALLOCATED
1	0		0011	<a href="#">INS (general)</a>
1	0		0101	<a href="#">SMOV</a>
1	0	x1000	0111	<a href="#">UMOV</a>
1	1			<a href="#">INS (element)</a>

### Advanced SIMD three same (FP16)

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	U	0	1	1	1	0	a	1	0	Rm				0	0	opcode				1	Rn				Rd					

Decode fields			Instruction Details	Feature
U	a	opcode		
0	0	000	<a href="#">FMAXNM (vector)</a>	FEAT_FP16
0	0	001	<a href="#">FMLA (vector)</a>	FEAT_FP16
0	0	010	<a href="#">FADD (vector)</a>	FEAT_FP16
0	0	011	<a href="#">FMULX</a>	FEAT_FP16
0	0	100	<a href="#">FCMEQ (register)</a>	FEAT_FP16
0	0	101	UNALLOCATED	-
0	0	110	<a href="#">FMAX (vector)</a>	FEAT_FP16
0	0	111	<a href="#">FRECPS</a>	FEAT_FP16
0	1	000	<a href="#">FMINNM (vector)</a>	FEAT_FP16
0	1	001	<a href="#">FMLS (vector)</a>	FEAT_FP16
0	1	010	<a href="#">FSUB (vector)</a>	FEAT_FP16
0	1	011	UNALLOCATED	-
0	1	100	UNALLOCATED	-
0	1	101	UNALLOCATED	-
0	1	110	<a href="#">FMIN (vector)</a>	FEAT_FP16
0	1	111	<a href="#">FRSQRTS</a>	FEAT_FP16
1	0	000	<a href="#">FMAXNMP (vector)</a>	FEAT_FP16
1	0	001	UNALLOCATED	-
1	0	010	<a href="#">FADDP (vector)</a>	FEAT_FP16
1	0	011	<a href="#">FMUL (vector)</a>	FEAT_FP16
1	0	100	<a href="#">FCMGE (register)</a>	FEAT_FP16
1	0	101	<a href="#">FACGE</a>	FEAT_FP16
1	0	110	<a href="#">FMAXP (vector)</a>	FEAT_FP16
1	0	111	<a href="#">FDIV (vector)</a>	FEAT_FP16
1	1	000	<a href="#">FMINNMP (vector)</a>	FEAT_FP16
1	1	001	UNALLOCATED	-
1	1	010	<a href="#">FABD</a>	FEAT_FP16
1	1	011	UNALLOCATED	-
1	1	100	<a href="#">FCMGT (register)</a>	FEAT_FP16
1	1	101	<a href="#">FACGT</a>	FEAT_FP16



Decode fields			Instruction Details	Feature
U	a	opcode		
1	1	110	<a href="#">FMINP (vector)</a>	FEAT_FP16
1	1	111	UNALLOCATED	-

### Advanced SIMD two-register miscellaneous (FP16)

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	U	0	1	1	1	0	a	1	1	1	1	0	0	opcode				1	0	Rn				Rd						

Decode fields			Instruction Details	Feature
U	a	opcode		
		00xxx	UNALLOCATED	-
		010xx	UNALLOCATED	-
		10xxx	UNALLOCATED	-
		11110	UNALLOCATED	-
	0	011xx	UNALLOCATED	-
	0	11111	UNALLOCATED	-
	1	11100	UNALLOCATED	-
0	0	11000	<a href="#">FRINTN (vector)</a>	FEAT_FP16
0	0	11001	<a href="#">FRINTM (vector)</a>	FEAT_FP16
0	0	11010	<a href="#">FCVTNS (vector)</a>	FEAT_FP16
0	0	11011	<a href="#">FCVTMS (vector)</a>	FEAT_FP16
0	0	11100	<a href="#">FCVTAS (vector)</a>	FEAT_FP16
0	0	11101	<a href="#">SCVTF (vector, integer)</a>	FEAT_FP16
0	1	01100	<a href="#">FCMGT (zero)</a>	FEAT_FP16
0	1	01101	<a href="#">FCMEQ (zero)</a>	FEAT_FP16
0	1	01110	<a href="#">FCMLT (zero)</a>	FEAT_FP16
0	1	01111	<a href="#">FABS (vector)</a>	FEAT_FP16
0	1	11000	<a href="#">FRINTP (vector)</a>	FEAT_FP16
0	1	11001	<a href="#">FRINTZ (vector)</a>	FEAT_FP16
0	1	11010	<a href="#">FCVTPS (vector)</a>	FEAT_FP16
0	1	11011	<a href="#">FCVTZS (vector, integer)</a>	FEAT_FP16
0	1	11101	<a href="#">FRECPE</a>	FEAT_FP16
0	1	11111	UNALLOCATED	-
1	0	11000	<a href="#">FRINTA (vector)</a>	FEAT_FP16
1	0	11001	<a href="#">FRINTX (vector)</a>	FEAT_FP16
1	0	11010	<a href="#">FCVTNU (vector)</a>	FEAT_FP16
1	0	11011	<a href="#">FCVTMU (vector)</a>	FEAT_FP16
1	0	11100	<a href="#">FCVTAU (vector)</a>	FEAT_FP16
1	0	11101	<a href="#">UCVTF (vector, integer)</a>	FEAT_FP16
1	1	01100	<a href="#">FCMGE (zero)</a>	FEAT_FP16
1	1	01101	<a href="#">FCMLE (zero)</a>	FEAT_FP16
1	1	01110	UNALLOCATED	-
1	1	01111	<a href="#">FNEG (vector)</a>	FEAT_FP16
1	1	11000	UNALLOCATED	-
1	1	11001	<a href="#">FRINTI (vector)</a>	FEAT_FP16
1	1	11010	<a href="#">FCVTPI (vector)</a>	FEAT_FP16
1	1	11011	<a href="#">FCVTZI (vector, integer)</a>	FEAT_FP16

Decode fields			Instruction Details	Feature
U	a	opcode		
1	1	11101	<a href="#">FRSQRT</a>	FEAT_FP16
1	1	11111	<a href="#">FSQRT (vector)</a>	FEAT_FP16

### Advanced SIMD three-register extension

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
0	Q	U	0	1	1	1	0	size	0	Rm						1	opcode						1	Rn						Rd					

Decode fields				Instruction Details	Feature
Q	U	size	opcode		
		0x	0011	UNALLOCATED	-
		11	0011	UNALLOCATED	-
	0		0000	UNALLOCATED	-
	0		0001	UNALLOCATED	-
	0		0010	<a href="#">SDOT (vector)</a>	FEAT_DotProd
	0		1xxx	UNALLOCATED	-
	0	10	0011	<a href="#">USDOT (vector)</a>	FEAT_I8MM
	1		0000	<a href="#">SQRDMLAH (vector)</a>	FEAT_RDM
	1		0001	<a href="#">SQRDMLSH (vector)</a>	FEAT_RDM
	1		0010	<a href="#">UDOT (vector)</a>	FEAT_DotProd
	1		10xx	<a href="#">FCMLA</a>	FEAT_FCMA
	1		11x0	<a href="#">FCADD</a>	FEAT_FCMA
	1	00	1101	UNALLOCATED	-
	1	00	1111	UNALLOCATED	-
	1	01	1111	<a href="#">BFDOT (vector)</a>	FEAT_BF16
	1	1x	1101	UNALLOCATED	-
	1	10	0011	UNALLOCATED	-
	1	10	1111	UNALLOCATED	-
	1	11	1111	<a href="#">BFMLALB, BFMLALT (vector)</a>	FEAT_BF16
0			01xx	UNALLOCATED	-
0	1	01	1101	UNALLOCATED	-
1		0x	01xx	UNALLOCATED	-
1		1x	011x	UNALLOCATED	-
1	0	10	0100	<a href="#">SMMLA (vector)</a>	FEAT_I8MM
1	0	10	0101	<a href="#">USMMLA (vector)</a>	FEAT_I8MM
1	1	01	1101	<a href="#">BFMMLA</a>	FEAT_BF16
1	1	10	0100	<a href="#">UMMLA (vector)</a>	FEAT_I8MM
1	1	10	0101	UNALLOCATED	-

### Advanced SIMD two-register miscellaneous

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	U	0	1	1	1	0	size	1	0	0	0	0		opcode					1	0		Rn					Rd			

U	Decode fields size opcode	Instruction Details	Feature
		1000x	UNALLOCATED
		10101	UNALLOCATED
	0x	011xx	UNALLOCATED
	1x	10111	UNALLOCATED
	1x	11110	UNALLOCATED
	11	10110	UNALLOCATED
0		00000	<a href="#">REV64</a>
0		00001	<a href="#">REV16 (vector)</a>
0		00010	<a href="#">SADDLP</a>
0		00011	<a href="#">SUQADD</a>
0		00100	<a href="#">CLS (vector)</a>
0		00101	<a href="#">CNT</a>
0		00110	<a href="#">SADALP</a>
0		00111	<a href="#">SQABS</a>
0		01000	<a href="#">CMGT (zero)</a>
0		01001	<a href="#">CMEQ (zero)</a>
0		01010	<a href="#">CMLT (zero)</a>
0		01011	<a href="#">ABS</a>
0		10010	<a href="#">XTN, XTN2</a>
0		10011	UNALLOCATED
0		10100	<a href="#">SQXTN, SQXTN2</a>
0	0x	10110	<a href="#">FCVTN, FCVTN2</a>
0	0x	10111	<a href="#">FCVTL, FCVTL2</a>
0	0x	11000	<a href="#">FRINTN (vector)</a>
0	0x	11001	<a href="#">FRINTM (vector)</a>
0	0x	11010	<a href="#">FCVTNS (vector)</a>
0	0x	11011	<a href="#">FCVTMS (vector)</a>
0	0x	11100	<a href="#">FCVTAS (vector)</a>
0	0x	11101	<a href="#">SCVTF (vector, integer)</a>
0	0x	11110	<a href="#">FRINT32Z (vector)</a>
0	0x	11111	<a href="#">FRINT64Z (vector)</a>
0	1x	01100	<a href="#">FCMGT (zero)</a>
0	1x	01101	<a href="#">FCMEQ (zero)</a>
0	1x	01110	<a href="#">FCMLT (zero)</a>
0	1x	01111	<a href="#">FABS (vector)</a>
0	1x	11000	<a href="#">FRINTP (vector)</a>
0	1x	11001	<a href="#">FRINTZ (vector)</a>
0	1x	11010	<a href="#">FCVTPS (vector)</a>
0	1x	11011	<a href="#">FCVTZS (vector, integer)</a>
0	1x	11100	<a href="#">URECPE</a>
0	1x	11101	<a href="#">FRECPE</a>
0	1x	11111	UNALLOCATED
0	10	10110	<a href="#">BFCVTN, BFCVTN2</a>
1		00000	<a href="#">REV32 (vector)</a>
1		00001	UNALLOCATED
1		00010	<a href="#">UADDLP</a>
1		00011	<a href="#">USQADD</a>

Decode fields			Instruction Details	Feature
U	size	opcode		
1		00100	<a href="#">CLZ (vector)</a>	-
1		00110	<a href="#">UADALP</a>	-
1		00111	<a href="#">SQNEG</a>	-
1		01000	<a href="#">CMGE (zero)</a>	-
1		01001	<a href="#">CMLE (zero)</a>	-
1		01010	UNALLOCATED	-
1		01011	<a href="#">NEG (vector)</a>	-
1		10010	<a href="#">SQXTUN, SQXTUN2</a>	-
1		10011	<a href="#">SHLL, SHLL2</a>	-
1		10100	<a href="#">UQXTN, UQXTN2</a>	-
1	0x	10110	<a href="#">FCVTXN, FCVTXN2</a>	-
1	0x	10111	UNALLOCATED	-
1	0x	11000	<a href="#">FRINTA (vector)</a>	-
1	0x	11001	<a href="#">FRINTX (vector)</a>	-
1	0x	11010	<a href="#">FCVTNU (vector)</a>	-
1	0x	11011	<a href="#">FCVTMU (vector)</a>	-
1	0x	11100	<a href="#">FCVTAU (vector)</a>	-
1	0x	11101	<a href="#">UCVTF (vector, integer)</a>	-
1	0x	11110	<a href="#">FRINT32X (vector)</a>	FEAT_FRINTTS
1	0x	11111	<a href="#">FRINT64X (vector)</a>	FEAT_FRINTTS
1	00	00101	<a href="#">NOT</a>	-
1	01	00101	<a href="#">RBIT (vector)</a>	-
1	1x	00101	UNALLOCATED	-
1	1x	01100	<a href="#">FCMGE (zero)</a>	-
1	1x	01101	<a href="#">FCMLE (zero)</a>	-
1	1x	01110	UNALLOCATED	-
1	1x	01111	<a href="#">FNEG (vector)</a>	-
1	1x	11000	UNALLOCATED	-
1	1x	11001	<a href="#">FRINTI (vector)</a>	-
1	1x	11010	<a href="#">FCVTPU (vector)</a>	-
1	1x	11011	<a href="#">FCVTZU (vector, integer)</a>	-
1	1x	11100	<a href="#">URSQRTE</a>	-
1	1x	11101	<a href="#">FRSQRTE</a>	-
1	1x	11111	<a href="#">FSQRT (vector)</a>	-
1	10	10110	UNALLOCATED	-

### Advanced SIMD across lanes

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	U	0	1	1	1	0	size	1	1	0	0	0	opcode			1		0	Rn				Rd							

Decode fields			Instruction Details	Feature
U	size	opcode		
		0000x	UNALLOCATED	-
		00010	UNALLOCATED	-
		001xx	UNALLOCATED	-
		0100x	UNALLOCATED	-

Decode fields			Instruction Details	Feature
U	size	opcode		
		01011	UNALLOCATED	-
		01101	UNALLOCATED	-
		01110	UNALLOCATED	-
		10xxx	UNALLOCATED	-
		1100x	UNALLOCATED	-
		111xx	UNALLOCATED	-
0		00011	<a href="#">SADDLV</a>	-
0		01010	<a href="#">SMAXV</a>	-
0		11010	<a href="#">SMINV</a>	-
0		11011	<a href="#">ADDV</a>	-
0	00	01100	<a href="#">FMAXNMV</a> — <a href="#">half-precision</a>	FEAT_FP16
0	00	01111	<a href="#">FMAXV</a> — <a href="#">half-precision</a>	FEAT_FP16
0	01	01100	UNALLOCATED	-
0	01	01111	UNALLOCATED	-
0	10	01100	<a href="#">FMINNMV</a> — <a href="#">half-precision</a>	FEAT_FP16
0	10	01111	<a href="#">FMINV</a> — <a href="#">half-precision</a>	FEAT_FP16
0	11	01100	UNALLOCATED	-
0	11	01111	UNALLOCATED	-
1		00011	<a href="#">UADDLV</a>	-
1		01010	<a href="#">UMAXV</a>	-
1		11010	<a href="#">UMINV</a>	-
1		11011	UNALLOCATED	-
1	0x	01100	<a href="#">FMAXNMV</a> — <a href="#">single-precision and double-precision</a>	-
1	0x	01111	<a href="#">FMAXV</a> — <a href="#">single-precision and double-precision</a>	-
1	1x	01100	<a href="#">FMINNMV</a> — <a href="#">single-precision and double-precision</a>	-
1	1x	01111	<a href="#">FMINV</a> — <a href="#">single-precision and double-precision</a>	-

### Advanced SIMD three different

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	U	0	1	1	1	0	size	1	Rm			opcode			0	0	Rn			Rd										

Decode fields		Instruction Details
U	opcode	
	1111	UNALLOCATED
0	0000	<a href="#">SADDL</a> , <a href="#">SADDL2</a>
0	0001	<a href="#">SADDW</a> , <a href="#">SADDW2</a>
0	0010	<a href="#">SSUBL</a> , <a href="#">SSUBL2</a>
0	0011	<a href="#">SSUBW</a> , <a href="#">SSUBW2</a>
0	0100	<a href="#">ADDHN</a> , <a href="#">ADDHN2</a>
0	0101	<a href="#">SABAL</a> , <a href="#">SABAL2</a>
0	0110	<a href="#">SUBHN</a> , <a href="#">SUBHN2</a>
0	0111	<a href="#">SABDL</a> , <a href="#">SABDL2</a>
0	1000	<a href="#">SMLAL</a> , <a href="#">SMLAL2 (vector)</a>
0	1001	<a href="#">SQDMLAL</a> , <a href="#">SQDMLAL2 (vector)</a>
0	1010	<a href="#">SMLSL</a> , <a href="#">SMLSL2 (vector)</a>
0	1011	<a href="#">SQDMLSL</a> , <a href="#">SQDMLSL2 (vector)</a>

Decode fields		Instruction Details
U	opcode	
0	1100	<a href="#">SMULL, SMULL2 (vector)</a>
0	1101	<a href="#">SQDMULL, SQDMULL2 (vector)</a>
0	1110	<a href="#">PMULL, PMULL2</a>
1	0000	<a href="#">UADDL, UADDL2</a>
1	0001	<a href="#">UADDW, UADDW2</a>
1	0010	<a href="#">USUBL, USUBL2</a>
1	0011	<a href="#">USUBW, USUBW2</a>
1	0100	<a href="#">RADDHN, RADDHN2</a>
1	0101	<a href="#">UABAL, UABAL2</a>
1	0110	<a href="#">RSUBHN, RSUBHN2</a>
1	0111	<a href="#">UABDL, UABDL2</a>
1	1000	<a href="#">UMLAL, UMLAL2 (vector)</a>
1	1001	UNALLOCATED
1	1010	<a href="#">UMLSL, UMLSL2 (vector)</a>
1	1011	UNALLOCATED
1	1100	<a href="#">UMULL, UMULL2 (vector)</a>
1	1101	UNALLOCATED
1	1110	UNALLOCATED

### Advanced SIMD three same

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	U	0	1	1	1	0	size	1	Rm					opcode					1	Rn					Rd					

Decode fields		Instruction Details	Feature
U	size opcode		
0		00000	<a href="#">SHADD</a>
0		00001	<a href="#">SQADD</a>
0		00010	<a href="#">SRHADD</a>
0		00100	<a href="#">SHSUB</a>
0		00101	<a href="#">SQSUB</a>
0		00110	<a href="#">CMGT (register)</a>
0		00111	<a href="#">CMGE (register)</a>
0		01000	<a href="#">SSHL</a>
0		01001	<a href="#">SQSHL (register)</a>
0		01010	<a href="#">SRSHL</a>
0		01011	<a href="#">SQRSHL</a>
0		01100	<a href="#">SMAX</a>
0		01101	<a href="#">SMIN</a>
0		01110	<a href="#">SABD</a>
0		01111	<a href="#">SABA</a>
0		10000	<a href="#">ADD (vector)</a>
0		10001	<a href="#">CMTST</a>
0		10010	<a href="#">MLA (vector)</a>
0		10011	<a href="#">MUL (vector)</a>
0		10100	<a href="#">SMAXP</a>
0		10101	<a href="#">SMINP</a>

U	Decode fields		Instruction Details	Feature
	size	opcode		
0		10110	<a href="#">SQDMULH (vector)</a>	-
0		10111	<a href="#">ADDP (vector)</a>	-
0	0x	11000	<a href="#">FMAXNM (vector)</a>	-
0	0x	11001	<a href="#">FMLA (vector)</a>	-
0	0x	11010	<a href="#">FADD (vector)</a>	-
0	0x	11011	<a href="#">FMULX</a>	-
0	0x	11100	<a href="#">FCMEQ (register)</a>	-
0	0x	11110	<a href="#">FMAX (vector)</a>	-
0	0x	11111	<a href="#">FRECPS</a>	-
0	00	00011	<a href="#">AND (vector)</a>	-
0	00	11101	<a href="#">FMLAL, FMLAL2 (vector)</a> — <a href="#">FMLAL</a>	FEAT_FHM
0	01	00011	<a href="#">BIC (vector, register)</a>	-
0	01	11101	UNALLOCATED	-
0	1x	11000	<a href="#">FMINNM (vector)</a>	-
0	1x	11001	<a href="#">FMLS (vector)</a>	-
0	1x	11010	<a href="#">FSUB (vector)</a>	-
0	1x	11011	UNALLOCATED	-
0	1x	11100	UNALLOCATED	-
0	1x	11110	<a href="#">FMIN (vector)</a>	-
0	1x	11111	<a href="#">FRSQRTS</a>	-
0	10	00011	<a href="#">ORR (vector, register)</a>	-
0	10	11101	<a href="#">FMLS, FMLS2 (vector)</a> — <a href="#">FMLS</a>	FEAT_FHM
0	11	00011	<a href="#">ORN (vector)</a>	-
0	11	11101	UNALLOCATED	-
1		00000	<a href="#">UHADD</a>	-
1		00001	<a href="#">UQADD</a>	-
1		00010	<a href="#">URHADD</a>	-
1		00100	<a href="#">UHSUB</a>	-
1		00101	<a href="#">UQSUB</a>	-
1		00110	<a href="#">CMHI (register)</a>	-
1		00111	<a href="#">CMHS (register)</a>	-
1		01000	<a href="#">USHL</a>	-
1		01001	<a href="#">UQSHL (register)</a>	-
1		01010	<a href="#">URSHL</a>	-
1		01011	<a href="#">UQRSHL</a>	-
1		01100	<a href="#">UMAX</a>	-
1		01101	<a href="#">UMIN</a>	-
1		01110	<a href="#">UABD</a>	-
1		01111	<a href="#">UABA</a>	-
1		10000	<a href="#">SUB (vector)</a>	-
1		10001	<a href="#">CMEQ (register)</a>	-
1		10010	<a href="#">MLS (vector)</a>	-
1		10011	<a href="#">PMUL</a>	-
1		10100	<a href="#">UMAXP</a>	-
1		10101	<a href="#">UMINP</a>	-
1		10110	<a href="#">SQRDMULH (vector)</a>	-
1		10111	UNALLOCATED	-

U	Decode fields size	opcode	Instruction Details	Feature
1	0x	11000	<a href="#">FMAXNMP (vector)</a>	-
1	0x	11010	<a href="#">FADDP (vector)</a>	-
1	0x	11011	<a href="#">FMUL (vector)</a>	-
1	0x	11100	<a href="#">FCMGE (register)</a>	-
1	0x	11101	<a href="#">FACGE</a>	-
1	0x	11110	<a href="#">FMAXP (vector)</a>	-
1	0x	11111	<a href="#">FDIV (vector)</a>	-
1	00	00011	<a href="#">EOR (vector)</a>	-
1	00	11001	<a href="#">FMLAL, FMLAL2 (vector)</a> — <a href="#">FMLAL2</a>	FEAT_FHM
1	01	00011	<a href="#">BSL</a>	-
1	01	11001	UNALLOCATED	-
1	1x	11000	<a href="#">FMINNMP (vector)</a>	-
1	1x	11010	<a href="#">FABD</a>	-
1	1x	11011	UNALLOCATED	-
1	1x	11100	<a href="#">FCMGT (register)</a>	-
1	1x	11101	<a href="#">FACGT</a>	-
1	1x	11110	<a href="#">FMINP (vector)</a>	-
1	1x	11111	UNALLOCATED	-
1	10	00011	<a href="#">BIT</a>	-
1	10	11001	<a href="#">FMLS, FMLS2 (vector)</a> — <a href="#">FMLS2</a>	FEAT_FHM
1	11	00011	<a href="#">BIF</a>	-
1	11	11001	UNALLOCATED	-

### Advanced SIMD modified immediate

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	op	0	1	1	1	1	0	0	0	0	0	a	b	c	cmode				o2	1	d	e	f	g	h	Rd				

Q	Decode fields op	cmode	o2	Instruction Details	Feature
	0	0xxx	1	UNALLOCATED	-
	0	0xx0	0	<a href="#">MOVI — 32-bit shifted immediate</a>	-
	0	0xx1	0	<a href="#">ORR (vector, immediate) — 32-bit</a>	-
	0	10xx	1	UNALLOCATED	-
	0	10x0	0	<a href="#">MOVI — 16-bit shifted immediate</a>	-
	0	10x1	0	<a href="#">ORR (vector, immediate) — 16-bit</a>	-
	0	110x	0	<a href="#">MOVI — 32-bit shifting ones</a>	-
	0	110x	1	UNALLOCATED	-
	0	1110	0	<a href="#">MOVI — 8-bit</a>	-
	0	1110	1	UNALLOCATED	-
	0	1111	0	<a href="#">FMOV (vector, immediate) — single-precision</a>	-
	0	1111	1	<a href="#">FMOV (vector, immediate) — half-precision</a>	FEAT_FP16
	1		1	UNALLOCATED	-
	1	0xx0	0	<a href="#">MVNI — 32-bit shifted immediate</a>	-
	1	0xx1	0	<a href="#">BIC (vector, immediate) — 32-bit</a>	-
	1	10x0	0	<a href="#">MVNI — 16-bit shifted immediate</a>	-
	1	10x1	0	<a href="#">BIC (vector, immediate) — 16-bit</a>	-



Decode fields				Instruction Details	Feature
Q	op	cmode	o2		
	1	110x	0	<a href="#">MVNI — 32-bit shifting ones</a>	-
0	1	1110	0	<a href="#">MOVI — 64-bit scalar</a>	-
0	1	1111	0	UNALLOCATED	-
1	1	1110	0	<a href="#">MOVI — 64-bit vector</a>	-
1	1	1111	0	<a href="#">FMOV (vector, immediate) — double-precision</a>	-

### Advanced SIMD shift by immediate

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	U	0	1	1	1	1	0	!= 0000				immb			opcode				1	Rn				Rd						
immh																															

The following constraints also apply to this encoding: immh != 0000 && immh != 0000

Decode fields		Instruction Details
U	opcode	
	00001	UNALLOCATED
	00011	UNALLOCATED
	00101	UNALLOCATED
	00111	UNALLOCATED
	01001	UNALLOCATED
	01011	UNALLOCATED
	01101	UNALLOCATED
	01111	UNALLOCATED
	10101	UNALLOCATED
	1011x	UNALLOCATED
	110xx	UNALLOCATED
	11101	UNALLOCATED
	11110	UNALLOCATED
0	00000	<a href="#">SSHR</a>
0	00010	<a href="#">SSRA</a>
0	00100	<a href="#">SRSHR</a>
0	00110	<a href="#">SRSRA</a>
0	01000	UNALLOCATED
0	01010	<a href="#">SHL</a>
0	01100	UNALLOCATED
0	01110	<a href="#">SQSHL (immediate)</a>
0	10000	<a href="#">SHRN, SHRN2</a>
0	10001	<a href="#">RSHRN, RSHRN2</a>
0	10010	<a href="#">SQSHRN, SQSHRN2</a>
0	10011	<a href="#">SQRSHRN, QQRSHRN2</a>
0	10100	<a href="#">SSHLL, SSHLL2</a>
0	11100	<a href="#">SCVTF (vector, fixed-point)</a>
0	11111	<a href="#">FCVTZS (vector, fixed-point)</a>
1	00000	<a href="#">USHR</a>
1	00010	<a href="#">USRA</a>
1	00100	<a href="#">URSHR</a>

Decode fields		Instruction Details
U	opcode	
1	00110	<a href="#">URSRA</a>
1	01000	<a href="#">SRI</a>
1	01010	<a href="#">SLI</a>
1	01100	<a href="#">SQSHLU</a>
1	01110	<a href="#">UQSHL (immediate)</a>
1	10000	<a href="#">SQSHRUN, SQSHRUN2</a>
1	10001	<a href="#">SQRSHRUN, SQRSHRUN2</a>
1	10010	<a href="#">UQSHRN, UQSHRN2</a>
1	10011	<a href="#">UQRSHRN, UQRSHRN2</a>
1	10100	<a href="#">USHLL, USHLL2</a>
1	11100	<a href="#">UCVTF (vector, fixed-point)</a>
1	11111	<a href="#">FCVTZU (vector, fixed-point)</a>

### Advanced SIMD vector x indexed element

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	U	0	1	1	1	1	size	L	M	Rm				opcode				H	0	Rn				Rd						

Decode fields			Instruction Details	Feature
U	size	opcode		
	01	1001	UNALLOCATED	-
0		0010	<a href="#">SMLAL, SMLAL2 (by element)</a>	-
0		0011	<a href="#">SQDMLAL, SQDMLAL2 (by element)</a>	-
0		0110	<a href="#">SMLSL, SMLSL2 (by element)</a>	-
0		0111	<a href="#">SQDMLSL, SQDMLSL2 (by element)</a>	-
0		1000	<a href="#">MUL (by element)</a>	-
0		1010	<a href="#">SMULL, SMULL2 (by element)</a>	-
0		1011	<a href="#">SQDMULL, SQDMULL2 (by element)</a>	-
0		1100	<a href="#">SQDMULH (by element)</a>	-
0		1101	<a href="#">SQRDMULH (by element)</a>	-
0		1110	<a href="#">SDOT (by element)</a>	FEAT_DotProd
0	0x	0000	UNALLOCATED	-
0	0x	0100	UNALLOCATED	-
0	00	0001	<a href="#">FMLA (by element) — half-precision</a>	FEAT_FP16
0	00	0101	<a href="#">FMLS (by element) — half-precision</a>	FEAT_FP16
0	00	1001	<a href="#">FMUL (by element) — half-precision</a>	FEAT_FP16
0	00	1111	<a href="#">SUDOT (by element)</a>	FEAT_I8MM
0	01	0001	UNALLOCATED	-
0	01	0101	UNALLOCATED	-
0	01	1111	<a href="#">BFDOT (by element)</a>	FEAT_BF16
0	1x	0001	<a href="#">FMLA (by element) — single-precision and double-precision</a>	-
0	1x	0101	<a href="#">FMLS (by element) — single-precision and double-precision</a>	-
0	1x	1001	<a href="#">FMUL (by element) — single-precision and double-precision</a>	-
0	10	0000	<a href="#">FMLAL, FMLAL2 (by element) — FMLAL</a>	FEAT_FHM
0	10	0100	<a href="#">FMLS, FMLS2 (by element) — FMLS</a>	FEAT_FHM
0	10	1111	<a href="#">USDOT (by element)</a>	FEAT_I8MM
0	11	0000	UNALLOCATED	-

Decode fields			Instruction Details	Feature
U	size	opcode		
0	11	0100	UNALLOCATED	-
0	11	1111	<a href="#">BFMLALB, BFMLALT (by element)</a>	FEAT_BF16
1		0000	<a href="#">MLA (by element)</a>	-
1		0010	<a href="#">UMLAL, UMLAL2 (by element)</a>	-
1		0100	<a href="#">MLS (by element)</a>	-
1		0110	<a href="#">UMLSL, UMLSL2 (by element)</a>	-
1		1010	<a href="#">UMULL, UMULL2 (by element)</a>	-
1		1011	UNALLOCATED	-
1		1101	<a href="#">SQRDMLAH (by element)</a>	FEAT_RDM
1		1110	<a href="#">UDOT (by element)</a>	FEAT_DotProd
1		1111	<a href="#">SQRDMLSH (by element)</a>	FEAT_RDM
1	0x	1000	UNALLOCATED	-
1	0x	1100	UNALLOCATED	-
1	00	0001	UNALLOCATED	-
1	00	0011	UNALLOCATED	-
1	00	0101	UNALLOCATED	-
1	00	0111	UNALLOCATED	-
1	00	1001	<a href="#">FMULX (by element) — half-precision</a>	FEAT_FP16
1	01	0xx1	<a href="#">FCMLA (by element)</a>	FEAT_FCMA
1	1x	1001	<a href="#">FMULX (by element) — single-precision and double-precision</a>	-
1	10	0xx1	<a href="#">FCMLA (by element)</a>	FEAT_FCMA
1	10	1000	<a href="#">FMLAL, FMLAL2 (by element) — FMLAL2</a>	FEAT_FHM
1	10	1100	<a href="#">FMLS, FMLS2 (by element) — FMLS2</a>	FEAT_FHM
1	11	0001	UNALLOCATED	-
1	11	0011	UNALLOCATED	-
1	11	0101	UNALLOCATED	-
1	11	0111	UNALLOCATED	-
1	11	1000	UNALLOCATED	-
1	11	1100	UNALLOCATED	-

## Cryptographic three-register, imm2

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	1	0	Rm					1	0	imm2	opcode	Rn					Rd						

Decode fields opcode	Instruction Details	Feature
00	<a href="#">SM3TT1A</a>	FEAT_SM3
01	<a href="#">SM3TT1B</a>	FEAT_SM3
10	<a href="#">SM3TT2A</a>	FEAT_SM3
11	<a href="#">SM3TT2B</a>	FEAT_SM3

## Cryptographic three-register SHA 512

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
1	1	0	0	1	1	1	0	0	1	1	Rm					1	0	0	0	opcode				Rn					Rd				

Decode fields		Instruction Details	Feature
O	opcode		
0	00	<a href="#">SHA512H</a>	FEAT_SHA512
0	01	<a href="#">SHA512H2</a>	FEAT_SHA512
0	10	<a href="#">SHA512SU1</a>	FEAT_SHA512
0	11	<a href="#">RAX1</a>	FEAT_SHA3
1	00	<a href="#">SM3PARTW1</a>	FEAT_SM3
1	01	<a href="#">SM3PARTW2</a>	FEAT_SM3
1	10	<a href="#">SM4EKEY</a>	FEAT_SM4
1	11	UNALLOCATED	-

## Cryptographic four-register

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	Op0				Rm		0				Ra							Rn					Rd

Decode fields Op0	Instruction Details	Feature
00	<a href="#">EOR3</a>	FEAT_SHA3
01	<a href="#">BCAX</a>	FEAT_SHA3
10	<a href="#">SM3SS1</a>	FEAT_SM3
11	UNALLOCATED	-

## Cryptographic two-register SHA 512

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	1	1	0	0	0	0	0	0	1	0	0	0	opcode		Rn					Rd				

Decode fields opcode	Instruction Details	Feature
00	<a href="#">SHA512SU0</a>	FEAT_SHA512
01	<a href="#">SM4E</a>	FEAT_SM4
1x	UNALLOCATED	-

## Conversion between floating-point and fixed-point

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0						
sf		0		S		1		1		1		1		0		ptype		0		rmode		opcode				scale				Rn				Rd			

sf	S	Decode fields			scale	Instruction Details	Feature
		p <sub>type</sub>	r <sub>mode</sub>	o <sub>pcode</sub>			
				1xx		UNALLOCATED	-
			x0	00x		UNALLOCATED	-
			x1	01x		UNALLOCATED	-
			0x	00x		UNALLOCATED	-
			1x	01x		UNALLOCATED	-
		10				UNALLOCATED	-
	1					UNALLOCATED	-

sf	S	Decode fields			scale	Instruction Details	Feature
		ptype	rmode	opcode			
0					0XXXXX	UNALLOCATED	-
0	0	00	00	010		<a href="#">SCVTF (scalar, fixed-point) — 32-bit to single-precision</a>	-
0	0	00	00	011		<a href="#">UCVTF (scalar, fixed-point) — 32-bit to single-precision</a>	-
0	0	00	11	000		<a href="#">FCVTZS (scalar, fixed-point) — single-precision to 32-bit</a>	-
0	0	00	11	001		<a href="#">FCVTZU (scalar, fixed-point) — single-precision to 32-bit</a>	-
0	0	01	00	010		<a href="#">SCVTF (scalar, fixed-point) — 32-bit to double-precision</a>	-
0	0	01	00	011		<a href="#">UCVTF (scalar, fixed-point) — 32-bit to double-precision</a>	-
0	0	01	11	000		<a href="#">FCVTZS (scalar, fixed-point) — double-precision to 32-bit</a>	-
0	0	01	11	001		<a href="#">FCVTZU (scalar, fixed-point) — double-precision to 32-bit</a>	-
0	0	11	00	010		<a href="#">SCVTF (scalar, fixed-point) — 32-bit to half-precision</a>	FEAT_FP16
0	0	11	00	011		<a href="#">UCVTF (scalar, fixed-point) — 32-bit to half-precision</a>	FEAT_FP16
0	0	11	11	000		<a href="#">FCVTZS (scalar, fixed-point) — half-precision to 32-bit</a>	FEAT_FP16
0	0	11	11	001		<a href="#">FCVTZU (scalar, fixed-point) — half-precision to 32-bit</a>	FEAT_FP16
1	0	00	00	010		<a href="#">SCVTF (scalar, fixed-point) — 64-bit to single-precision</a>	-
1	0	00	00	011		<a href="#">UCVTF (scalar, fixed-point) — 64-bit to single-precision</a>	-
1	0	00	11	000		<a href="#">FCVTZS (scalar, fixed-point) — single-precision to 64-bit</a>	-
1	0	00	11	001		<a href="#">FCVTZU (scalar, fixed-point) — single-precision to 64-bit</a>	-
1	0	01	00	010		<a href="#">SCVTF (scalar, fixed-point) — 64-bit to double-precision</a>	-
1	0	01	00	011		<a href="#">UCVTF (scalar, fixed-point) — 64-bit to double-precision</a>	-
1	0	01	11	000		<a href="#">FCVTZS (scalar, fixed-point) — double-precision to 64-bit</a>	-
1	0	01	11	001		<a href="#">FCVTZU (scalar, fixed-point) — double-precision to 64-bit</a>	-
1	0	11	00	010		<a href="#">SCVTF (scalar, fixed-point) — 64-bit to half-precision</a>	FEAT_FP16
1	0	11	00	011		<a href="#">UCVTF (scalar, fixed-point) — 64-bit to half-precision</a>	FEAT_FP16
1	0	11	11	000		<a href="#">FCVTZS (scalar, fixed-point) — half-precision to 64-bit</a>	FEAT_FP16
1	0	11	11	001		<a href="#">FCVTZU (scalar, fixed-point) — half-precision to 64-bit</a>	FEAT_FP16

## Conversion between floating-point and integer

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	S	1	1	1	1	0	ptype	1	rmode	opcode	0	0	0	0	0	0	0	0	0	0	Rn				Rd					

sf	Decode fields			opcode	Instruction Details	Feature
	S	ptype	rmode			
			x1	01x	UNALLOCATED	-
			x1	10x	UNALLOCATED	-
			1x	01x	UNALLOCATED	-
			1x	10x	UNALLOCATED	-
	0	10		0xx	UNALLOCATED	-
	0	10		10x	UNALLOCATED	-
	1				UNALLOCATED	-
0	0	00	x1	11x	UNALLOCATED	-
0	0	00	00	000	<a href="#">FCVTNS (scalar) — single-precision to 32-bit</a>	-
0	0	00	00	001	<a href="#">FCVTNU (scalar) — single-precision to 32-bit</a>	-
0	0	00	00	010	<a href="#">SCVTF (scalar, integer) — 32-bit to single-precision</a>	-
0	0	00	00	011	<a href="#">UCVTF (scalar, integer) — 32-bit to single-precision</a>	-
0	0	00	00	100	<a href="#">FCVTAS (scalar) — single-precision to 32-bit</a>	-
0	0	00	00	101	<a href="#">FCVTAU (scalar) — single-precision to 32-bit</a>	-
0	0	00	00	110	<a href="#">FMOV (general) — single-precision to 32-bit</a>	-
0	0	00	00	111	<a href="#">FMOV (general) — 32-bit to single-precision</a>	-
0	0	00	01	000	<a href="#">FCVTPS (scalar) — single-precision to 32-bit</a>	-
0	0	00	01	001	<a href="#">FCVTPU (scalar) — single-precision to 32-bit</a>	-
0	0	00	1x	11x	UNALLOCATED	-
0	0	00	10	000	<a href="#">FCVTMS (scalar) — single-precision to 32-bit</a>	-
0	0	00	10	001	<a href="#">FCVTMU (scalar) — single-precision to 32-bit</a>	-
0	0	00	11	000	<a href="#">FCVTZS (scalar, integer) — single-precision to 32-bit</a>	-
0	0	00	11	001	<a href="#">FCVTZU (scalar, integer) — single-precision to 32-bit</a>	-
0	0	01	0x	11x	UNALLOCATED	-
0	0	01	00	000	<a href="#">FCVTNS (scalar) — double-precision to 32-bit</a>	-
0	0	01	00	001	<a href="#">FCVTNU (scalar) — double-precision to 32-bit</a>	-
0	0	01	00	010	<a href="#">SCVTF (scalar, integer) — 32-bit to double-precision</a>	-
0	0	01	00	011	<a href="#">UCVTF (scalar, integer) — 32-bit to double-precision</a>	-
0	0	01	00	100	<a href="#">FCVTAS (scalar) — double-precision to 32-bit</a>	-
0	0	01	00	101	<a href="#">FCVTAU (scalar) — double-precision to 32-bit</a>	-
0	0	01	01	000	<a href="#">FCVTPS (scalar) — double-precision to 32-bit</a>	-
0	0	01	01	001	<a href="#">FCVTPU (scalar) — double-precision to 32-bit</a>	-
0	0	01	10	000	<a href="#">FCVTMS (scalar) — double-precision to 32-bit</a>	-
0	0	01	10	001	<a href="#">FCVTMU (scalar) — double-precision to 32-bit</a>	-
0	0	01	10	11x	UNALLOCATED	-
0	0	01	11	000	<a href="#">FCVTZS (scalar, integer) — double-precision to 32-bit</a>	-
0	0	01	11	001	<a href="#">FCVTZU (scalar, integer) — double-precision to 32-bit</a>	-
0	0	01	11	110	<a href="#">EJCVTZS</a>	FEAT_JSCVT
0	0	01	11	111	UNALLOCATED	-
0	0	10		11x	UNALLOCATED	-
0	0	11	00	000	<a href="#">FCVTNS (scalar) — half-precision to 32-bit</a>	FEAT_FP16
0	0	11	00	001	<a href="#">FCVTNU (scalar) — half-precision to 32-bit</a>	FEAT_FP16
0	0	11	00	010	<a href="#">SCVTF (scalar, integer) — 32-bit to half-precision</a>	FEAT_FP16
0	0	11	00	011	<a href="#">UCVTF (scalar, integer) — 32-bit to half-precision</a>	FEAT_FP16
0	0	11	00	100	<a href="#">FCVTAS (scalar) — half-precision to 32-bit</a>	FEAT_FP16
0	0	11	00	101	<a href="#">FCVTAU (scalar) — half-precision to 32-bit</a>	FEAT_FP16
0	0	11	00	110	<a href="#">FMOV (general) — half-precision to 32-bit</a>	FEAT_FP16

sf	S	Decode fields		opcode	Instruction Details	Feature
		ptype	rmode			
0	0	11	00	111	<a href="#">FMOV (general) — 32-bit to half-precision</a>	FEAT_FP16
0	0	11	01	000	<a href="#">FCVTPS (scalar) — half-precision to 32-bit</a>	FEAT_FP16
0	0	11	01	001	<a href="#">FCVTPU (scalar) — half-precision to 32-bit</a>	FEAT_FP16
0	0	11	10	000	<a href="#">FCVTMS (scalar) — half-precision to 32-bit</a>	FEAT_FP16
0	0	11	10	001	<a href="#">FCVTMU (scalar) — half-precision to 32-bit</a>	FEAT_FP16
0	0	11	11	000	<a href="#">FCVTZS (scalar, integer) — half-precision to 32-bit</a>	FEAT_FP16
0	0	11	11	001	<a href="#">FCVTZU (scalar, integer) — half-precision to 32-bit</a>	FEAT_FP16
1	0	00		11x	UNALLOCATED	-
1	0	00	00	000	<a href="#">FCVTNS (scalar) — single-precision to 64-bit</a>	-
1	0	00	00	001	<a href="#">FCVTNU (scalar) — single-precision to 64-bit</a>	-
1	0	00	00	010	<a href="#">SCVTF (scalar, integer) — 64-bit to single-precision</a>	-
1	0	00	00	011	<a href="#">UCVTF (scalar, integer) — 64-bit to single-precision</a>	-
1	0	00	00	100	<a href="#">FCVTAS (scalar) — single-precision to 64-bit</a>	-
1	0	00	00	101	<a href="#">FCVTAU (scalar) — single-precision to 64-bit</a>	-
1	0	00	01	000	<a href="#">FCVTPS (scalar) — single-precision to 64-bit</a>	-
1	0	00	01	001	<a href="#">FCVTPU (scalar) — single-precision to 64-bit</a>	-
1	0	00	10	000	<a href="#">FCVTMS (scalar) — single-precision to 64-bit</a>	-
1	0	00	10	001	<a href="#">FCVTMU (scalar) — single-precision to 64-bit</a>	-
1	0	00	11	000	<a href="#">FCVTZS (scalar, integer) — single-precision to 64-bit</a>	-
1	0	00	11	001	<a href="#">FCVTZU (scalar, integer) — single-precision to 64-bit</a>	-
1	0	01	x1	11x	UNALLOCATED	-
1	0	01	00	000	<a href="#">FCVTNS (scalar) — double-precision to 64-bit</a>	-
1	0	01	00	001	<a href="#">FCVTNU (scalar) — double-precision to 64-bit</a>	-
1	0	01	00	010	<a href="#">SCVTF (scalar, integer) — 64-bit to double-precision</a>	-
1	0	01	00	011	<a href="#">UCVTF (scalar, integer) — 64-bit to double-precision</a>	-
1	0	01	00	100	<a href="#">FCVTAS (scalar) — double-precision to 64-bit</a>	-
1	0	01	00	101	<a href="#">FCVTAU (scalar) — double-precision to 64-bit</a>	-
1	0	01	00	110	<a href="#">FMOV (general) — double-precision to 64-bit</a>	-
1	0	01	00	111	<a href="#">FMOV (general) — 64-bit to double-precision</a>	-
1	0	01	01	000	<a href="#">FCVTPS (scalar) — double-precision to 64-bit</a>	-
1	0	01	01	001	<a href="#">FCVTPU (scalar) — double-precision to 64-bit</a>	-
1	0	01	1x	11x	UNALLOCATED	-
1	0	01	10	000	<a href="#">FCVTMS (scalar) — double-precision to 64-bit</a>	-
1	0	01	10	001	<a href="#">FCVTMU (scalar) — double-precision to 64-bit</a>	-
1	0	01	11	000	<a href="#">FCVTZS (scalar, integer) — double-precision to 64-bit</a>	-
1	0	01	11	001	<a href="#">FCVTZU (scalar, integer) — double-precision to 64-bit</a>	-
1	0	10	x0	11x	UNALLOCATED	-
1	0	10	01	110	<a href="#">FMOV (general) — top half of 128-bit to 64-bit</a>	-
1	0	10	01	111	<a href="#">FMOV (general) — 64-bit to top half of 128-bit</a>	-
1	0	10	1x	11x	UNALLOCATED	-
1	0	11	00	000	<a href="#">FCVTNS (scalar) — half-precision to 64-bit</a>	FEAT_FP16
1	0	11	00	001	<a href="#">FCVTNU (scalar) — half-precision to 64-bit</a>	FEAT_FP16
1	0	11	00	010	<a href="#">SCVTF (scalar, integer) — 64-bit to half-precision</a>	FEAT_FP16
1	0	11	00	011	<a href="#">UCVTF (scalar, integer) — 64-bit to half-precision</a>	FEAT_FP16
1	0	11	00	100	<a href="#">FCVTAS (scalar) — half-precision to 64-bit</a>	FEAT_FP16
1	0	11	00	101	<a href="#">FCVTAU (scalar) — half-precision to 64-bit</a>	FEAT_FP16
1	0	11	00	110	<a href="#">FMOV (general) — half-precision to 64-bit</a>	FEAT_FP16

Decode fields					Instruction Details	Feature
sf	S	ptype	rmode	opcode		
1	0	11	00	111	<a href="#">FMOV (general) — 64-bit to half-precision</a>	FEAT_FP16
1	0	11	01	000	<a href="#">FCVTPS (scalar) — half-precision to 64-bit</a>	FEAT_FP16
1	0	11	01	001	<a href="#">FCVTPU (scalar) — half-precision to 64-bit</a>	FEAT_FP16
1	0	11	10	000	<a href="#">FCVTMS (scalar) — half-precision to 64-bit</a>	FEAT_FP16
1	0	11	10	001	<a href="#">FCVTMU (scalar) — half-precision to 64-bit</a>	FEAT_FP16
1	0	11	11	000	<a href="#">FCVTZS (scalar, integer) — half-precision to 64-bit</a>	FEAT_FP16
1	0	11	11	001	<a href="#">FCVTZU (scalar, integer) — half-precision to 64-bit</a>	FEAT_FP16

### Floating-point data-processing (1 source)

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	0	S	1	1	1	1	0	ptype	1	opcode					1	0	0	0	0	Rn				Rd							

Decode fields				Instruction Details	Feature
M	S	ptype	opcode		
			1xxxxx	UNALLOCATED	-
	1			UNALLOCATED	-
0	0	00	000000	<a href="#">FMOV (register) — single-precision</a>	-
0	0	00	000001	<a href="#">FABS (scalar) — single-precision</a>	-
0	0	00	000010	<a href="#">FNEG (scalar) — single-precision</a>	-
0	0	00	000011	<a href="#">FSQRT (scalar) — single-precision</a>	-
0	0	00	000100	UNALLOCATED	-
0	0	00	000101	<a href="#">FCVT — single-precision to double-precision</a>	-
0	0	00	000110	UNALLOCATED	-
0	0	00	000111	<a href="#">FCVT — single-precision to half-precision</a>	-
0	0	00	001000	<a href="#">FRINTN (scalar) — single-precision</a>	-
0	0	00	001001	<a href="#">FRINTP (scalar) — single-precision</a>	-
0	0	00	001010	<a href="#">FRINTM (scalar) — single-precision</a>	-
0	0	00	001011	<a href="#">FRINTZ (scalar) — single-precision</a>	-
0	0	00	001100	<a href="#">FRINTA (scalar) — single-precision</a>	-
0	0	00	001101	UNALLOCATED	-
0	0	00	001110	<a href="#">FRINTX (scalar) — single-precision</a>	-
0	0	00	001111	<a href="#">FRINTI (scalar) — single-precision</a>	-
0	0	00	010000	<a href="#">FRINT32Z (scalar) — single-precision</a>	FEAT_FRINTTS
0	0	00	010001	<a href="#">FRINT32X (scalar) — single-precision</a>	FEAT_FRINTTS
0	0	00	010010	<a href="#">FRINT64Z (scalar) — single-precision</a>	FEAT_FRINTTS
0	0	00	010011	<a href="#">FRINT64X (scalar) — single-precision</a>	FEAT_FRINTTS
0	0	00	0101xx	UNALLOCATED	-
0	0	00	011xxx	UNALLOCATED	-
0	0	01	000000	<a href="#">FMOV (register) — double-precision</a>	-
0	0	01	000001	<a href="#">FABS (scalar) — double-precision</a>	-
0	0	01	000010	<a href="#">FNEG (scalar) — double-precision</a>	-
0	0	01	000011	<a href="#">FSQRT (scalar) — double-precision</a>	-
0	0	01	000100	<a href="#">FCVT — double-precision to single-precision</a>	-
0	0	01	000101	UNALLOCATED	-
0	0	01	000110	<a href="#">BFCVT</a>	FEAT_BF16
0	0	01	000111	<a href="#">FCVT — double-precision to half-precision</a>	-



Decode fields				Instruction Details	Feature
M	S	ptype	opcode		
0	0	01	001000	<a href="#">FRINTN (scalar) — double-precision</a>	-
0	0	01	001001	<a href="#">FRINTP (scalar) — double-precision</a>	-
0	0	01	001010	<a href="#">FRINTM (scalar) — double-precision</a>	-
0	0	01	001011	<a href="#">FRINTZ (scalar) — double-precision</a>	-
0	0	01	001100	<a href="#">FRINTA (scalar) — double-precision</a>	-
0	0	01	001101	UNALLOCATED	-
0	0	01	001110	<a href="#">FRINTX (scalar) — double-precision</a>	-
0	0	01	001111	<a href="#">FRINTI (scalar) — double-precision</a>	-
0	0	01	010000	<a href="#">FRINT32Z (scalar) — double-precision</a>	FEAT_FRINTTS
0	0	01	010001	<a href="#">FRINT32X (scalar) — double-precision</a>	FEAT_FRINTTS
0	0	01	010010	<a href="#">FRINT64Z (scalar) — double-precision</a>	FEAT_FRINTTS
0	0	01	010011	<a href="#">FRINT64X (scalar) — double-precision</a>	FEAT_FRINTTS
0	0	01	0101xx	UNALLOCATED	-
0	0	01	011xxx	UNALLOCATED	-
0	0	10	0xxxxx	UNALLOCATED	-
0	0	11	000000	<a href="#">FMOV (register) — half-precision</a>	FEAT_FP16
0	0	11	000001	<a href="#">FABS (scalar) — half-precision</a>	FEAT_FP16
0	0	11	000010	<a href="#">FNEG (scalar) — half-precision</a>	FEAT_FP16
0	0	11	000011	<a href="#">FSQRT (scalar) — half-precision</a>	FEAT_FP16
0	0	11	000100	<a href="#">FCVT — half-precision to single-precision</a>	-
0	0	11	000101	<a href="#">FCVT — half-precision to double-precision</a>	-
0	0	11	00011x	UNALLOCATED	-
0	0	11	001000	<a href="#">FRINTN (scalar) — half-precision</a>	FEAT_FP16
0	0	11	001001	<a href="#">FRINTP (scalar) — half-precision</a>	FEAT_FP16
0	0	11	001010	<a href="#">FRINTM (scalar) — half-precision</a>	FEAT_FP16
0	0	11	001011	<a href="#">FRINTZ (scalar) — half-precision</a>	FEAT_FP16
0	0	11	001100	<a href="#">FRINTA (scalar) — half-precision</a>	FEAT_FP16
0	0	11	001101	UNALLOCATED	-
0	0	11	001110	<a href="#">FRINTX (scalar) — half-precision</a>	FEAT_FP16
0	0	11	001111	<a href="#">FRINTI (scalar) — half-precision</a>	FEAT_FP16
0	0	11	01xxxx	UNALLOCATED	-
1				UNALLOCATED	-

## Floating-point compare

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	0	S	1	1	1	1	0	ptype	1	Rm				op	1	0	0	0	Rn				opcode2								

Decode fields				Instruction Details	Feature
M	S	ptype	op		
				xxxx1	UNALLOCATED
				xxx1x	UNALLOCATED
				xx1xx	UNALLOCATED
			x1	UNALLOCATED	-
			1x	UNALLOCATED	-
		10		UNALLOCATED	-
	1			UNALLOCATED	-

M	S	Decode fields		opcode2	Instruction Details	Feature
		p <sub>type</sub>	op			
0	0	00	00	00000	<a href="#">FCMP</a>	-
0	0	00	00	01000	<a href="#">FCMP</a>	-
0	0	00	00	10000	<a href="#">FCMPE</a>	-
0	0	00	00	11000	<a href="#">FCMPE</a>	-
0	0	01	00	00000	<a href="#">FCMP</a>	-
0	0	01	00	01000	<a href="#">FCMP</a>	-
0	0	01	00	10000	<a href="#">FCMPE</a>	-
0	0	01	00	11000	<a href="#">FCMPE</a>	-
0	0	11	00	00000	<a href="#">FCMP</a>	FEAT_FP16
0	0	11	00	01000	<a href="#">FCMP</a>	FEAT_FP16
0	0	11	00	10000	<a href="#">FCMPE</a>	FEAT_FP16
0	0	11	00	11000	<a href="#">FCMPE</a>	FEAT_FP16
1					UNALLOCATED	-

## Floating-point immediate

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	0	S	1	1	1	1	0	p	t	y	e	1	imm8								1	0	0	imm5				Rd			

M	S	Decode fields		Instruction Details	Feature
		p <sub>type</sub>	imm5		
			xxxx1	UNALLOCATED	-
			xxx1x	UNALLOCATED	-
			xx1xx	UNALLOCATED	-
			x1xxx	UNALLOCATED	-
			1xxxx	UNALLOCATED	-
		10		UNALLOCATED	-
	1			UNALLOCATED	-
0	0	00	00000	<a href="#">FMOV (scalar, immediate) — single-precision</a>	-
0	0	01	00000	<a href="#">FMOV (scalar, immediate) — double-precision</a>	-
0	0	11	00000	<a href="#">FMOV (scalar, immediate) — half-precision</a>	FEAT_FP16
1				UNALLOCATED	-

## Floating-point conditional compare

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	0	S	1	1	1	1	0	p <sub>type</sub>	1	Rm				cond		0	1	Rn				op	nzc <sub>v</sub>								

M	S	Decode fields		Instruction Details	Feature
		p <sub>type</sub>	op		
		10		UNALLOCATED	-
	1			UNALLOCATED	-
0	0	00	0	<a href="#">FCCMP — single-precision</a>	-
0	0	00	1	<a href="#">FCCMPE — single-precision</a>	-
0	0	01	0	<a href="#">FCCMP — double-precision</a>	-
0	0	01	1	<a href="#">FCCMPE — double-precision</a>	-

Decode fields				Instruction Details	Feature
M	S	ptype	op		
0	0	11	0	<a href="#">FCCMP</a> — <a href="#">half-precision</a>	FEAT_FP16
0	0	11	1	<a href="#">FCCMPE</a> — <a href="#">half-precision</a>	FEAT_FP16
1				UNALLOCATED	-

## Floating-point data-processing (2 source)

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	0	S	1	1	1	1	0	ptype	1	Rm						opcode						1	0	Rn						Rd	

Decode fields				Instruction Details	Feature
M	S	ptype	opcode		
			1xx1	UNALLOCATED	-
			1x1x	UNALLOCATED	-
			11xx	UNALLOCATED	-
		10		UNALLOCATED	-
	1			UNALLOCATED	-
0	0	00	0000	<a href="#">FMUL (scalar)</a> — <a href="#">single-precision</a>	-
0	0	00	0001	<a href="#">FDIV (scalar)</a> — <a href="#">single-precision</a>	-
0	0	00	0010	<a href="#">FADD (scalar)</a> — <a href="#">single-precision</a>	-
0	0	00	0011	<a href="#">FSUB (scalar)</a> — <a href="#">single-precision</a>	-
0	0	00	0100	<a href="#">FMAX (scalar)</a> — <a href="#">single-precision</a>	-
0	0	00	0101	<a href="#">FMIN (scalar)</a> — <a href="#">single-precision</a>	-
0	0	00	0110	<a href="#">FMAXNM (scalar)</a> — <a href="#">single-precision</a>	-
0	0	00	0111	<a href="#">FMINNM (scalar)</a> — <a href="#">single-precision</a>	-
0	0	00	1000	<a href="#">FNMUL (scalar)</a> — <a href="#">single-precision</a>	-
0	0	01	0000	<a href="#">FMUL (scalar)</a> — <a href="#">double-precision</a>	-
0	0	01	0001	<a href="#">FDIV (scalar)</a> — <a href="#">double-precision</a>	-
0	0	01	0010	<a href="#">FADD (scalar)</a> — <a href="#">double-precision</a>	-
0	0	01	0011	<a href="#">FSUB (scalar)</a> — <a href="#">double-precision</a>	-
0	0	01	0100	<a href="#">FMAX (scalar)</a> — <a href="#">double-precision</a>	-
0	0	01	0101	<a href="#">FMIN (scalar)</a> — <a href="#">double-precision</a>	-
0	0	01	0110	<a href="#">FMAXNM (scalar)</a> — <a href="#">double-precision</a>	-
0	0	01	0111	<a href="#">FMINNM (scalar)</a> — <a href="#">double-precision</a>	-
0	0	01	1000	<a href="#">FNMUL (scalar)</a> — <a href="#">double-precision</a>	-
0	0	11	0000	<a href="#">FMUL (scalar)</a> — <a href="#">half-precision</a>	FEAT_FP16
0	0	11	0001	<a href="#">FDIV (scalar)</a> — <a href="#">half-precision</a>	FEAT_FP16
0	0	11	0010	<a href="#">FADD (scalar)</a> — <a href="#">half-precision</a>	FEAT_FP16
0	0	11	0011	<a href="#">FSUB (scalar)</a> — <a href="#">half-precision</a>	FEAT_FP16
0	0	11	0100	<a href="#">FMAX (scalar)</a> — <a href="#">half-precision</a>	FEAT_FP16
0	0	11	0101	<a href="#">FMIN (scalar)</a> — <a href="#">half-precision</a>	FEAT_FP16
0	0	11	0110	<a href="#">FMAXNM (scalar)</a> — <a href="#">half-precision</a>	FEAT_FP16
0	0	11	0111	<a href="#">FMINNM (scalar)</a> — <a href="#">half-precision</a>	FEAT_FP16
0	0	11	1000	<a href="#">FNMUL (scalar)</a> — <a href="#">half-precision</a>	FEAT_FP16
1				UNALLOCATED	-

## Floating-point conditional select

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	0	S	1	1	1	1	0	ptype	1	Rm				cond				1	1	Rn				Rd							

Decode fields			Instruction Details		Feature
M	S	ptype			
		10	UNALLOCATED		-
	1		UNALLOCATED		-
0	0	00	<a href="#">FCSEL — single-precision</a>		-
0	0	01	<a href="#">FCSEL — double-precision</a>		-
0	0	11	<a href="#">FCSEL — half-precision</a>		FEAT_FP16
1			UNALLOCATED		-

## Floating-point data-processing (3 source)

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	0	S	1	1	1	1	1	ptype	o1	Rm				o0	Ra				Rn				Rd								

Decode fields					Instruction Details		Feature
M	S	ptype	o1	o0			
		10			UNALLOCATED		-
	1				UNALLOCATED		-
0	0	00	0	0	<a href="#">FMADD — single-precision</a>		-
0	0	00	0	1	<a href="#">FMSUB — single-precision</a>		-
0	0	00	1	0	<a href="#">FNMADD — single-precision</a>		-
0	0	00	1	1	<a href="#">FNMSUB — single-precision</a>		-
0	0	01	0	0	<a href="#">FMADD — double-precision</a>		-
0	0	01	0	1	<a href="#">FMSUB — double-precision</a>		-
0	0	01	1	0	<a href="#">FNMADD — double-precision</a>		-
0	0	01	1	1	<a href="#">FNMSUB — double-precision</a>		-
0	0	11	0	0	<a href="#">FMADD — half-precision</a>		FEAT_FP16
0	0	11	0	1	<a href="#">FMSUB — half-precision</a>		FEAT_FP16
0	0	11	1	0	<a href="#">FNMADD — half-precision</a>		FEAT_FP16
0	0	11	1	1	<a href="#">FNMSUB — half-precision</a>		FEAT_FP16
1					UNALLOCATED		-

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.

## Shared Pseudocode Functions

This page displays common pseudocode functions shared by many pages

### Pseudocodes

#### Library pseudocode for aarch32/debug/VCRMatch/AArch32.VCRMatch

```
// AArch32.VCRMatch()
// =====

boolean AArch32.VCRMatch(bits(32) vaddress)

if UsingAArch32() && ELUsingAArch32(EL1) && PSTATE.EL != EL2 then
    // Each bit position in this string corresponds to a bit in DBGVCR and an exception vector.
    match_word = Zeros(32);

    if vaddress<31:5> == ExcVectorBase()<31:5> then
        if HaveEL(EL3) && !IsSecure() then
            match_word<UInt(vaddress<4:2>) + 24> = '1';        // Non-secure vectors
        else
            match_word<UInt(vaddress<4:2>) + 0> = '1';        // Secure vectors (or no EL3)

    if HaveEL(EL3) && ELUsingAArch32(EL3) && IsSecure() && vaddress<31:5> == MVBAR<31:5> then
        match_word<UInt(vaddress<4:2>) + 8> = '1';        // Monitor vectors

    // Mask out bits not corresponding to vectors.
    if !HaveEL(EL3) then
        mask = '00000000':'00000000':'00000000':'11011110'; // DBGVCR[31:8] are RES0
    elseif !ELUsingAArch32(EL3) then
        mask = '11011110':'00000000':'00000000':'11011110'; // DBGVCR[15:8] are RES0
    else
        mask = '11011110':'00000000':'11011100':'11011110';

    match_word = match_word AND DBGVCR AND mask;
    match = !IsZero(match_word);

    // Check for UNPREDICTABLE case - match on Prefetch Abort and Data Abort vectors
    if !IsZero(match_word<28:27,12:11,4:3>) && DebugTarget() == PSTATE.EL then
        match = ConstrainUnpredictableBool(Unpredictable_VCMATCHDAPA);

    if !IsZero(vaddress<1:0>) && match then
        match = ConstrainUnpredictableBool(Unpredictable_VCMATCHHALF);
else
    match = FALSE;

return match;
```

#### Library pseudocode for aarch32/debug/authentication/ AArch32.SelfHostedSecurePrivilegedInvasiveDebugEnabled

```
// AArch32.SelfHostedSecurePrivilegedInvasiveDebugEnabled()
// =====

boolean AArch32.SelfHostedSecurePrivilegedInvasiveDebugEnabled()
    // The definition of this function is IMPLEMENTATION DEFINED.
    // In the recommended interface, AArch32.SelfHostedSecurePrivilegedInvasiveDebugEnabled returns
    // the state of the (DBGEN AND SPIDEN) signal.
    if !HaveEL(EL3) && !IsSecure() then return FALSE;
    return DBGEN == HIGH && SPIDEN == HIGH;
```

## Library pseudocode for aarch32/debug/breakpoint/AArch32.BreakpointMatch

```
// AArch32.BreakpointMatch()
// =====
// Breakpoint matching in an AArch32 translation regime.

(boolean,boolean) AArch32.BreakpointMatch(integer n, bits(32) vaddress, integer size)
    assert ELUsingAArch32\(S1TranslationRegime\(\)\);
    assert n < GetNumBreakpoints\(\);

    enabled = DBGBCR[n].E == '1';
    ispriv = PSTATE.EL != EL0;
    linked = DBGBCR[n].BT == '0x01';
    isbreakpnt = TRUE;
    linked_to = FALSE;

    state_match = AArch32.StateMatch(DBGBCR[n].SSC, DBGBCR[n].HMC, DBGBCR[n].PMC,
                                    linked, DBGBCR[n].LBN, isbreakpnt, ispriv);
    (value_match, value_mismatch) = AArch32.BreakpointValueMatch(n, vaddress, linked_to);

    if size == 4 then // Check second halfword
        // If the breakpoint address and BAS of an Address breakpoint match the address of the
        // second halfword of an instruction, but not the address of the first halfword, it is
        // CONSTRAINED UNPREDICTABLE whether or not this breakpoint generates a Breakpoint debug
        // event.
        (match_i, mismatch_i) = AArch32.BreakpointValueMatch(n, vaddress + 2, linked_to);
        if !value_match && match_i then
            value_match = ConstrainUnpredictableBool(Unpredictable_BPMATCHHALF);
        if value_mismatch && !mismatch_i then
            value_mismatch = ConstrainUnpredictableBool(Unpredictable_BPMISMATCHHALF);
    if vaddress<1> == '1' && DBGBCR[n].BAS == '1111' then
        // The above notwithstanding, if DBGBCR[n].BAS == '1111', then it is CONSTRAINED
        // UNPREDICTABLE whether or not a Breakpoint debug event is generated for an instruction
        // at the address DBGBCR[n]+2.
        if value_match then value_match = ConstrainUnpredictableBool(Unpredictable_BPMATCHHALF);
        if !value_mismatch then value_mismatch = ConstrainUnpredictableBool(Unpredictable_BPMISMATCHHALF);

    match = value_match && state_match && enabled;
    mismatch = value_mismatch && state_match && enabled;

    return (match, mismatch);
```



```

// AArch32.BreakpointValueMatch()
// =====
// The first result is whether an Address Match or Context breakpoint is programmed on the
// instruction at "address". The second result is whether an Address Mismatch breakpoint is
// programmed on the instruction, that is, whether the instruction should be stepped.

(boolean,boolean) AArch32.BreakpointValueMatch(integer n, bits(32) vaddress, boolean linked_to)

// "n" is the identity of the breakpoint unit to match against.
// "vaddress" is the current instruction address, ignored if linked_to is TRUE and for Context
// matching breakpoints.
// "linked_to" is TRUE if this is a call from StateMatch for linking.

// If a non-existent breakpoint then it is CONSTRAINED UNPREDICTABLE whether this gives
// no match or the breakpoint is mapped to another UNKNOWN implemented breakpoint.
if n >= GetNumBreakpoints() then
    (c, n) = ConstrainUnpredictableInteger(0, GetNumBreakpoints() - 1, Unpredictable_BPNOTIMPL);
    assert c IN {Constraint_DISABLED, Constraint_UNKNOWN};
    if c == Constraint_DISABLED then return (FALSE,FALSE);

// If this breakpoint is not enabled, it cannot generate a match. (This could also happen on a
// call from StateMatch for linking).
if DBGBCR[n].E == '0' then return (FALSE,FALSE);

context_aware = (n >= (GetNumBreakpoints() - GetNumContextAwareBreakpoints()));

// If BT is set to a reserved type, behaves either as disabled or as a not-reserved type.
dbgtype = DBGBCR[n].BT;

if ((dbgtype IN {'011x','11xx'}) && !HaveVirtHostExt() && !HaveV82Debug()) || // Context matching
    (dbgtype == '010x' && HaltOnBreakpointOrWatchpoint()) || // Address mismatch
    (dbgtype != '0x0x' && !context_aware) || // Context matching
    (dbgtype == '1xxx' && !HaveEL(EL2))) then // EL2 extension
    (c, dbgtype) = ConstrainUnpredictableBits(Unpredictable_RESBPTYPE);
    assert c IN {Constraint_DISABLED, Constraint_UNKNOWN};
    if c == Constraint_DISABLED then return (FALSE,FALSE);
    // Otherwise the value returned by ConstrainUnpredictableBits must be a not-reserved value

// Determine what to compare against.
match_addr = (dbgtype == '0x0x');
mismatch   = (dbgtype == '010x');
match_vmid = (dbgtype == '10xx');
match_cid1 = (dbgtype == 'xx1x');
match_cid2 = (dbgtype == '11xx');
linked      = (dbgtype == 'xxx1');

// If this is a call from StateMatch, return FALSE if the breakpoint is not programmed for a
// VMID and/or context ID match, or if not context-aware. The above assertions mean that the
// code can just test for match_addr == TRUE to confirm all these things.
if linked_to && (!linked || match_addr) then return (FALSE,FALSE);

// If called from BreakpointMatch return FALSE for Linked context ID and/or VMID matches.
if !linked_to && linked && !match_addr then return (FALSE,FALSE);

// Do the comparison.
if match_addr then
    byte = UInt(vaddress<1:0>);
    assert byte IN {0,2}; // "vaddress" is halfword aligned
    byte_select_match = (DBGBCR[n].BAS<byte> == '1');
    integer top = 31;
    BVR_match = (vaddress<top:2> == DBGBCR[n]<top:2>) && byte_select_match;

elseif match_cid1 then
    BVR_match = (PSTATE.EL != EL2 && CONTEXTIDR == DBGBCR[n]<31:0>);
if match_vmid then
    if ELUsingAArch32(EL2) then
        vmid = ZeroExtend(VTTBR.VMID, 16);
        bvr_vmid = ZeroExtend(DBGBCR[n]<7:0>, 16);
    elseif !Have16bitVMID() || VTCR.EL2.VS == '0' then
        vmid = ZeroExtend(VTTBR_EL2.VMID<7:0>, 16);

```



```

        bvr_vmid = ZeroExtend(DBGBXVR[n]<7:0>, 16);
    else
        vmid = VTTBR_EL2.VMID;
        bvr_vmid = DBGBXVR[n]<15:0>;
        BXVR_match = (PSTATE.EL IN {EL0, EL1} && EL2Enabled() &&
            vmid == bvr_vmid);
    elsif match_cid2 then
        BXVR_match = ((HaveVirtHostExt() || HaveV82Debug()) && EL2Enabled() &&
            !ELUsingAArch32(EL2) &&
            DBGBXVR[n]<31:0> == CONTEXTIDR_EL2<31:0>);

    bvr_match_valid = (match_addr || match_cid1);
    bxvr_match_valid = (match_vmid || match_cid2);

    match = (!bxvr_match_valid || BXVR_match) && (!bvr_match_valid || BVR_match);

    return (match && !mismatch, !match && mismatch);

```

## Library pseudocode for aarch32/debug/breakpoint/AArch32.StateMatch

```
// AArch32.StateMatch()
// =====
// Determine whether a breakpoint or watchpoint is enabled in the current mode and state.

boolean AArch32.StateMatch(bits(2) SSC, bit HMC, bits(2) PxC, boolean linked, bits(4) LBN,
                           boolean isbreakpt, boolean ispriv)
// "SSC", "HMC", "PxC" are the control fields from the DBGBCR[n] or DBGWCR[n] register.
// "linked" is TRUE if this is a linked breakpoint/watchpoint type.
// "LBN" is the linked breakpoint number from the DBGBCR[n] or DBGWCR[n] register.
// "isbreakpt" is TRUE for breakpoints, FALSE for watchpoints.
// "ispriv" is valid for watchpoints, and selects between privileged and unprivileged accesses.

// If parameters are set to a reserved type, behaves as either disabled or a defined type
(c, SSC, HMC, PxC) = CheckValidStateMatch(SSC, HMC, PxC, isbreakpt);
if c == Constraint_DISABLED then return FALSE;
// Otherwise the HMC,SSC,PxC values are either valid or the values returned by
// CheckValidStateMatch are valid.

PL2_match = HaveEL(EL2) && ((HMC == '1' && (SSC:PxC != '1000')) || SSC == '11');
PL1_match = PxC<0> == '1';
PL0_match = PxC<1> == '1';
SSU_match = isbreakpt && HMC == '0' && PxC == '00' && SSC != '11';

if !ispriv && !isbreakpt then
    priv_match = PL0_match;
elsif SSU_match then
    priv_match = PSTATE.M IN {M32_User,M32_Svc,M32_System};
else
    case PSTATE.EL of
        when EL3 priv_match = PL1_match;           // EL3 and EL1 are both PL1
        when EL2 priv_match = PL2_match;
        when EL1 priv_match = PL1_match;
        when EL0 priv_match = PL0_match;

    case SSC of
        when '00' security_state_match = TRUE;           // Both
        when '01' security_state_match = !IsSecure();     // Non-secure only
        when '10' security_state_match = IsSecure();      // Secure only
        when '11' security_state_match = (HMC == '1' || IsSecure()); // HMC=1 -> Both, 0 -> Secure only

    if linked then
        // "LBN" must be an enabled context-aware breakpoint unit. If it is not context-aware then
        // it is CONSTRAINED UNPREDICTABLE whether this gives no match, or LBN is mapped to some
        // UNKNOWN breakpoint that is context-aware.
        lbn = UInt(LBN);
        first_ctx_cmp = GetNumBreakpoints() - GetNumContextAwareBreakpoints();
        last_ctx_cmp = GetNumBreakpoints() - 1;
        if (lbn < first_ctx_cmp || lbn > last_ctx_cmp) then
            (c, lbn) = ConstrainUnpredictableInteger(first_ctx_cmp, last_ctx_cmp, Unpredictable_BPN0TCTX);
            assert c IN {Constraint_DISABLED, Constraint_NONE, Constraint_UNKNOWN};
            case c of
                when Constraint_DISABLED return FALSE; // Disabled
                when Constraint_NONE linked = FALSE; // No linking
            // Otherwise ConstrainUnpredictableInteger returned a context-aware breakpoint

    if linked then
        vaddress = bits(32) UNKNOWN;
        linked_to = TRUE;
        (linked_match,-) = AArch32.BreakpointValueMatch(lbn, vaddress, linked_to);

    return priv_match && security_state_match && (!linked || linked_match);
```

## Library pseudocode for aarch32/debug/enables/AArch32.GenerateDebugExceptions

```
// AArch32.GenerateDebugExceptions()
// =====

boolean AArch32.GenerateDebugExceptions()
    return AArch32.GenerateDebugExceptionsFrom(PSTATE.EL, IsSecure());
```

## Library pseudocode for aarch32/debug/enables/AArch32.GenerateDebugExceptionsFrom

```
// AArch32.GenerateDebugExceptionsFrom()
// =====

boolean AArch32.GenerateDebugExceptionsFrom(bits(2) from, boolean secure)

    if !ELUsingAArch32(DebugTargetFrom(secure)) then
        mask = '0'; // No PSTATE.D in AArch32 state
        return AArch64.GenerateDebugExceptionsFrom(from, secure, mask);

    if DBGOSLSR.OSLK == '1' || DoubleLockStatus() || Halted() then
        return FALSE;

    if HaveEL(EL3) && secure then
        assert from != EL2; // Secure EL2 always uses AArch64
        if IsSecureEL2Enabled() then
            // Implies that EL3 and EL2 both using AArch64
            enabled = MDCR_EL3.SDD == '0';
        else
            spd = if ELUsingAArch32(EL3) then SDCR.SPD else MDCR_EL3.SPD32;
            if spd<1> == '1' then
                enabled = spd<0> == '1';
            else
                // SPD == 0b01 is reserved, but behaves the same as 0b00.
                enabled = AArch32.SelfHostedSecurePrivilegedInvasiveDebugEnabled();
        if from == EL0 then enabled = enabled || SDER.SUIDEN == '1';
    else
        enabled = from != EL2;

    return enabled;
```

## Library pseudocode for aarch32/debug/pmu/AArch32.CheckForPMUOverflow

```
// AArch32.CheckForPMUOverflow()
// =====
// Signal Performance Monitors overflow IRQ and CTI overflow events

boolean AArch32.CheckForPMUOverflow()

    if !ELUsingAArch32(EL1) then return AArch64.CheckForPMUOverflow();
    pmuirq = PMCR.E == '1' && PMINTENSET<31> == '1' && PMOVSSET<31> == '1';
    for n = 0 to GetNumEventCounters() - 1
        if HaveEL(EL2) then
            hpmn = if !ELUsingAArch32(EL2) then MDCR_EL2.HPMN else HDCR.HPMN;
            hpme = if !ELUsingAArch32(EL2) then MDCR_EL2.HPME else HDCR.HPME;
            E = (if n < UInt(hpmn) then PMCR.E else hpme);
        else
            E = PMCR.E;
        if E == '1' && PMINTENSET<n> == '1' && PMOVSSET<n> == '1' then pmuirq = TRUE;

    SetInterruptRequestLevel(InterruptID_PMUIRQ, if pmuirq then HIGH else LOW);
    CTI_SetEventLevel(CrossTriggerIn_PMUOverflow, if pmuirq then HIGH else LOW);

    // The request remains set until the condition is cleared. (For example, an interrupt handler
    // or cross-triggered event handler clears the overflow status flag by writing to PMOVSLR_EL0.)

    return pmuirq;
```



```

// AArch32.CountEvents()
// =====
// Return TRUE if counter "n" should count its event. For the cycle counter, n == 31.

boolean AArch32.CountEvents(integer n)
    assert n == 31 || n < GetNumEventCounters\(\);

    if !ELUsingAArch32\(EL1\) then return AArch64.CountEvents\(n\);

    // Event counting is disabled in Debug state
    debug = Halted\(\);

    // In Non-secure state, some counters are reserved for EL2
    if HaveEL\(EL2\) then
        hpmn = if !ELUsingAArch32\(EL2\) then MDCR_EL2.HPMN else HDCR.HPMN;
        hpme = if !ELUsingAArch32\(EL2\) then MDCR_EL2.HPME else HDCR.HPME;
        resvd_for_el2 = n >= UInt\(hpmn\) && n != 31;
    else
        resvd_for_el2 = FALSE;

    // Main enable controls
    if resvd_for_el2 then
        E = if ELUsingAArch32\(EL2\) then HDCR.HPME else MDCR_EL2.HPME;
    else
        E = PMCR.E;
    enabled = E == '1' && PMCNTENSET<n> == '1';

    // Event counting is allowed unless it is prohibited by any rule below
    prohibited = FALSE;
    // Event counting in Secure state is prohibited if all of:
    // * EL3 is implemented
    // * One of the following is true:
    //   - EL3 is using AArch64, MDCR_EL3.SPME == 0, and either:
    //     - FEAT_PMuV3p7 is not implemented
    //     - MDCR_EL3.MPMX == 0
    //   - EL3 is using AArch32 and SDCR.SPME == 0
    // * Not executing at EL0, or SDER.SUNIDEN == 0
    if HaveEL\(EL3\) && IsSecure\(\) then
        spme = if ELUsingAArch32\(EL3\) then SDCR.SPME else MDCR_EL3.SPME;
        if !ELUsingAArch32\(EL3\) && HavePMuV3p7\(\) then
            prohibited = spme == '0' && MDCR_EL3.MPMX == '0';
        else
            prohibited = spme == '0';
        if prohibited && PSTATE.EL == EL0 then
            prohibited = SDER.SUNIDEN == '0';

    // Event counting at EL2 is prohibited if all of:
    // * The HPMD Extension is implemented
    // * PMNx is not reserved for EL2
    // * HDCR.HPMD == 1
    if !prohibited && PSTATE.EL == EL2 && HaveHPMDExt\(\) && !resvd_for_el2 then
        prohibited = HDCR.HPMD == '1';

    // The IMPLEMENTATION DEFINED authentication interface might override software
    if prohibited && !HaveNoSecurePMUDisableOverride\(\) then
        prohibited = !ExternalSecureNoninvasiveDebugEnabled\(\);

    // PMCR.DP disables the cycle counter when event counting is prohibited
    if enabled && prohibited && n == 31 then
        enabled = PMCR.DP == '0';

    // If FEAT_PMuV3p5 is implemented, cycle counting can be prohibited.
    // This is not overridden by PMCR.DP.
    if Havev85PMU\(\) && n == 31 then
        if HaveEL\(EL3\) && IsSecure\(\) then
            sccd = if ELUsingAArch32\(EL3\) then SDCR.SCCD else MDCR_EL3.SCCD;
            if sccd == '1' then prohibited = TRUE;
        if PSTATE.EL == EL2 && HDCR.HCCD == '1' then
            prohibited = TRUE;

```

```

// Event counting might be frozen
frozen = FALSE;

// If FEAT_PMUV3p7 is implemented, event counting can be frozen
if HavePMUV3p7() && n != 31 then
    ovflw = PM0VSR<GetNumEventCounters()-1:0>;
    if resvd_for_el2 then
        FZ = if ELUsingAArch32(EL2) then HDCR.HPMFZ0 else MDCR_EL2.HPMFZ0;
        ovflw<UInt(hpmn)-1:0> = Zeros();
    else
        FZ = PMCR.FZ0;
        if HaveEL(EL2) then
            ovflw<GetNumEventCounters()-1:UInt(hpmn)> = Zeros();
        frozen = FZ == '1' && !IsZero(ovflw);

// Event counting can be filtered by the {P, U, NSK, NSU, NSH} bits
filter = if n == 31 then PMCCFILTR else PMEVTYPER[n];

P = filter<31>;
U = filter<30>;
NSK = if HaveEL(EL3) then filter<29> else '0';
NSU = if HaveEL(EL3) then filter<28> else '0';
NSH = if HaveEL(EL2) then filter<27> else '0';

case PSTATE.EL of
    when EL0 filtered = if IsSecure() then U == '1' else U != NSU;
    when EL1 filtered = if IsSecure() then P == '1' else P != NSK;
    when EL2 filtered = NSH == '0';
    when EL3 filtered = P == '1';

return !debug && enabled && !prohibited && !filtered && !frozen;

```

## Library pseudocode for aarch32/debug/takeexceptiondbg/AArch32.EnterHypModeInDebugState

```

// AArch32.EnterHypModeInDebugState()
// =====
// Take an exception in Debug state to Hyp mode.

AArch32.EnterHypModeInDebugState(ExceptionRecord exception)
    SynchronizeContext();
    assert HaveEL(EL2) && !IsSecure() && ELUsingAArch32(EL2);

    AArch32.ReportHypEntry(exception);
    AArch32.WriteMode(M32_Hyp);
    SPSR[] = bits(32) UNKNOWN;
    ELR_hyp = bits(32) UNKNOWN;
    // In Debug state, the PE always execute T32 instructions when in AArch32 state, and
    // PSTATE.{SS,A,I,F} are not observable so behave as UNKNOWN.
    PSTATE.T = '1'; // PSTATE.J is RES0
    PSTATE.<SS,A,I,F> = bits(4) UNKNOWN;
    DLR = bits(32) UNKNOWN;
    DSPSR = bits(32) UNKNOWN;
    PSTATE.E = HSCTLR.EE;
    PSTATE.IL = '0';
    PSTATE.IT = '00000000';
    if HaveSSBSExt() then PSTATE.SSBS = bit UNKNOWN;
    EDSCR.ERR = '1';
    UpdateEDSCRFields();

    EndOfInstruction();

```

## Library pseudocode for aarch32/debug/takeexceptiondbg/AArch32.EnterModeInDebugState

```
// AArch32.EnterModeInDebugState()
// =====
// Take an exception in Debug state to a mode other than Monitor and Hyp mode.

AArch32.EnterModeInDebugState(bits(5) target_mode)
    SynchronizeContext();
    assert ELUsingAArch32(EL1) && PSTATE.EL != EL2;

    if PSTATE.M == M32_Monitor then SCR.NS = '0';
    AArch32.WriteMode(target_mode);
    SPSR[] = bits(32) UNKNOWN;
    R[14] = bits(32) UNKNOWN;
    // In Debug state, the PE always execute T32 instructions when in AArch32 state, and
    // PSTATE.{SS,A,I,F} are not observable so behave as UNKNOWN.
    PSTATE.T = '1'; // PSTATE.J is RES0
    PSTATE.<SS,A,I,F> = bits(4) UNKNOWN;
    DLR = bits(32) UNKNOWN;
    DSPSR = bits(32) UNKNOWN;
    PSTATE.E = SCTLR.EE;
    PSTATE.IL = '0';
    PSTATE.IT = '00000000';
    if HavePANExt() && SCTLR.SPAN == '0' then PSTATE.PAN = '1';
    if HaveSSBSExt() then PSTATE.SSBS = bit UNKNOWN;
    EDSCR.ERR = '1';
    UpdateEDSCRFields(); // Update EDSCR processor state flags.

    EndOfInstruction();
```

## Library pseudocode for aarch32/debug/takeexceptiondbg/AArch32.EnterMonitorModeInDebugState

```
// AArch32.EnterMonitorModeInDebugState()
// =====
// Take an exception in Debug state to Monitor mode.

AArch32.EnterMonitorModeInDebugState()
    SynchronizeContext();
    assert HaveEL(EL3) && ELUsingAArch32(EL3);
    from_secure = IsSecure();
    if PSTATE.M == M32_Monitor then SCR.NS = '0';
    AArch32.WriteMode(M32_Monitor);
    SPSR[] = bits(32) UNKNOWN;
    R[14] = bits(32) UNKNOWN;
    // In Debug state, the PE always execute T32 instructions when in AArch32 state, and
    // PSTATE.{SS,A,I,F} are not observable so behave as UNKNOWN.
    PSTATE.T = '1'; // PSTATE.J is RES0
    PSTATE.<SS,A,I,F> = bits(4) UNKNOWN;
    PSTATE.E = SCTLR.EE;
    PSTATE.IL = '0';
    PSTATE.IT = '00000000';
    if HavePANExt() then
        if !from_secure then
            PSTATE.PAN = '0';
        elsif SCTLR.SPAN == '0' then
            PSTATE.PAN = '1';
    if HaveSSBSExt() then PSTATE.SSBS = bit UNKNOWN;
    DLR = bits(32) UNKNOWN;
    DSPSR = bits(32) UNKNOWN;
    EDSCR.ERR = '1';
    UpdateEDSCRFields(); // Update EDSCR processor state flags.

    EndOfInstruction();
```

## Library pseudocode for aarch32/debug/watchpoint/AArch32.WatchpointByteMatch

```
// AArch32.WatchpointByteMatch()
// =====

boolean AArch32.WatchpointByteMatch(integer n, bits(32) vaddress)

integer top = 31;
bottom = if DBGWVR[n]<2> == '1' then 2 else 3;           // Word or doubleword
byte_select_match = (DBGWCR[n].BAS<UInt(vaddress<bottom-1:0>)> != '0');
mask = UInt(DBGWCR[n].MASK);

// If DBGWCR[n].MASK is non-zero value and DBGWCR[n].BAS is not set to '11111111', or
// DBGWCR[n].BAS specifies a non-contiguous set of bytes behavior is CONSTRAINED
// UNPREDICTABLE.
if mask > 0 && !IsOnes(DBGWCR[n].BAS) then
    byte_select_match = ConstrainUnpredictableBool(Unpredictable_WPMASKANDBAS);
else
    LSB = (DBGWCR[n].BAS AND NOT(DBGWCR[n].BAS - 1)); MSB = (DBGWCR[n].BAS + LSB);
    if !IsZero(MSB AND (MSB - 1)) then                // Not contiguous
        byte_select_match = ConstrainUnpredictableBool(Unpredictable_WPBASCONTIGUOUS);
        bottom = 3;                                   // For the whole doubleword

// If the address mask is set to a reserved value, the behavior is CONSTRAINED UNPREDICTABLE.
if mask > 0 && mask <= 2 then
    (c, mask) = ConstrainUnpredictableInteger(3, 31, Unpredictable_RESWPMASK);
    assert c IN {Constraint_DISABLED, Constraint_NONE, Constraint_UNKNOWN};
    case c of
        when Constraint_DISABLED return FALSE;        // Disabled
        when Constraint_NONE     mask = 0;            // No masking
        // Otherwise the value returned by ConstrainUnpredictableInteger is a not-reserved value

if mask > bottom then
    // If the DBGxVR<n>_EL1.RESS field bits are not a sign extension of the MSB
    // of DBGxVR<n>_EL1.VA, it is UNPREDICTABLE whether they appear to be
    // included in the match.
    if !IsOnes(DBGxVR_EL1[n]<63:top>) && !IsZero(DBGxVR_EL1[n]<63:top>) then
        if ConstrainUnpredictableBool(Unpredictable_DBGxVR_RESS) then
            top = 63;
        WVR_match = (vaddress<top:mask> == DBGWVR[n]<top:mask>);
        // If masked bits of DBGWVR_EL1[n] are not zero, the behavior is CONSTRAINED UNPREDICTABLE.
        if WVR_match && !IsZero(DBGWVR[n]<mask-1:bottom>) then
            WVR_match = ConstrainUnpredictableBool(Unpredictable_WPMASKEDBITS);
    else
        WVR_match = vaddress<top:bottom> == DBGWVR[n]<top:bottom>;

return WVR_match && byte_select_match;
```



## Library pseudocode for aarch32/debug/watchpoint/AArch32.WatchpointMatch

```
// AArch32.WatchpointMatch()
// =====
// Watchpoint matching in an AArch32 translation regime.

boolean AArch32.WatchpointMatch(integer n, bits(32) vaddress, integer size, boolean ispriv,
                                AccType acctype, boolean iswrite)
    assert ELUsingAArch32(S1TranslationRegime());
    assert n < GetNumWatchpoints();

    // "ispriv" is:
    // * FALSE for all loads, stores, and atomic operations executed at EL0.
    // * FALSE if the access is unprivileged.
    // * TRUE for all other loads, stores, and atomic operations.

    enabled = DBGWCR[n].E == '1';
    linked = DBGWCR[n].WT == '1';
    isbreakpnt = FALSE;

    state_match = AArch32.StateMatch(DBGWCR[n].SSC, DBGWCR[n].HMC, DBGWCR[n].PAC,
                                     linked, DBGWCR[n].LBN, isbreakpnt, ispriv);
    ls_match = FALSE;
    ls_match = (DBGWCR[n].LSC<(if iswrite then 1 else 0)> == '1');

    value_match = FALSE;
    for byte = 0 to size - 1
        value_match = value_match || AArch32.WatchpointByteMatch(n, vaddress + byte);

    return value_match && state_match && ls_match && enabled;
```

## Library pseudocode for aarch32/exceptions/aborts/AArch32.Abort

```
// AArch32.Abort()
// =====
// Abort and Debug exception handling in an AArch32 translation regime.

AArch32.Abort(bits(32) vaddress, FaultRecord fault)

    // Check if routed to AArch64 state
    route_to_aarch64 = PSTATE.EL == EL0 && !ELUsingAArch32(EL1);

    if !route_to_aarch64 && EL2Enabled() && !ELUsingAArch32(EL2) then
        route_to_aarch64 = (HCR_EL2.TGE == '1' || IsSecondStage(fault) ||
                           (HaveRASExt() && HCR_EL2.TEA == '1' && IsExternalAbort(fault)) ||
                           (IsDebugException(fault) && MDCR_EL2.TDE == '1'));

    if !route_to_aarch64 && HaveEL(EL3) && !ELUsingAArch32(EL3) then
        route_to_aarch64 = SCR_EL3.EA == '1' && IsExternalAbort(fault);

    if route_to_aarch64 then
        AArch64.Abort(ZeroExtend(vaddress), fault);
    elsif fault.acctype == AccType_IFETCH then
        AArch32.TakePrefetchAbortException(vaddress, fault);
    else
        AArch32.TakeDataAbortException(vaddress, fault);
```

## Library pseudocode for aarch32/exceptions/aborts/AArch32.AbortSyndrome

```
// AArch32.AbortSyndrome()
// =====
// Creates an exception syndrome record for Abort exceptions taken to Hyp mode
// from an AArch32 translation regime.

ExceptionRecord AArch32.AbortSyndrome(Exception exceptype, FaultRecord fault, bits(32) vaddress)
    exception = ExceptionSyndrome(exceptype);

    d_side = exceptype == Exception_DataAbort;

    exception.syndrome = AArch32.FaultSyndrome(d_side, fault);
    exception.vaddress = ZeroExtend(vaddress);
    if IPAValid(fault) then
        exception.ipavalid = TRUE;
        exception.NS = if fault.ipaddress.paspace == PAS_NonSecure then '1' else '0';
        exception.ipaddress = ZeroExtend(fault.ipaddress.address);
    else
        exception.ipavalid = FALSE;

    return exception;
```

## Library pseudocode for aarch32/exceptions/aborts/AArch32.CheckPCAlignment

```
// AArch32.CheckPCAlignment()
// =====

AArch32.CheckPCAlignment()

    bits(32) pc = ThisInstrAddr();
    if (CurrentInstrSet() == InstrSet_A32 && pc<1> == '1') || pc<0> == '1' then
        if AArch32.GeneralExceptionsToAArch64() then AArch64.PCAlignmentFault();

        // Generate an Alignment fault Prefetch Abort exception
        vaddress = pc;
        acctype = AccType_IFETCH;
        iswrite = FALSE;
        secondstage = FALSE;
        AArch32.Abort(vaddress, AlignmentFault(acctype, iswrite, secondstage));
```

## Library pseudocode for aarch32/exceptions/aborts/AArch32.ReportDataAbort

```
// AArch32.ReportDataAbort()
// =====
// Report syndrome information for aborts taken to modes other than Hyp mode.

AArch32.ReportDataAbort(boolean route_to_monitor, FaultRecord fault, bits(32) vaddress)

    // The encoding used in the IFSR or DFSR can be Long-descriptor format or Short-descriptor
    // format. Normally, the current translation table format determines the format. For an abort
    // from Non-secure state to Monitor mode, the IFSR or DFSR uses the Long-descriptor format if
    // any of the following applies:
    // * The Secure TTBCR.EAE is set to 1.
    // * The abort is synchronous and either:
    //   - It is taken from Hyp mode.
    //   - It is taken from EL1 or EL0, and the Non-secure TTBCR.EAE is set to 1.
    long_format = FALSE;
    if route_to_monitor && !IsSecure() then
        long_format = TTBCR_S.EAE == '1';
        if !IsSErrorInterrupt(fault) && !long_format then
            long_format = PSTATE.EL == EL2 || TTBCR.EAE == '1';
    else
        long_format = TTBCR.EAE == '1';
    d_side = TRUE;
    if long_format then
        syndrome = AArch32.FaultStatusLD(d_side, fault);
    else
        syndrome = AArch32.FaultStatusSD(d_side, fault);

    if fault.acctype == AccType_IC then
        if (!long_format &&
            boolean IMPLEMENTATION_DEFINED "Report I-cache maintenance fault in IFSR") then
            i_syndrome = syndrome;
            syndrome<10,3:0> = EncodeSDFSC(Fault_ICacheMaint, 1);
        else
            i_syndrome = bits(32) UNKNOWN;
        if route_to_monitor then
            IFSR_S = i_syndrome;
        else
            IFSR = i_syndrome;

    if route_to_monitor then
        DFSR_S = syndrome;
        DFAR_S = vaddress;
    else
        DFSR = syndrome;
        DFAR = vaddress;

    return;
```

## Library pseudocode for aarch32/exceptions/aborts/AArch32.ReportPrefetchAbort

```
// AArch32.ReportPrefetchAbort()
// =====
// Report syndrome information for aborts taken to modes other than Hyp mode.

AArch32.ReportPrefetchAbort(boolean route_to_monitor, FaultRecord fault, bits(32) vaddress)
    // The encoding used in the IFSR can be Long-descriptor format or Short-descriptor format.
    // Normally, the current translation table format determines the format. For an abort from
    // Non-secure state to Monitor mode, the IFSR uses the Long-descriptor format if any of the
    // following applies:
    // * The Secure TTBCR.EAE is set to 1.
    // * It is taken from Hyp mode.
    // * It is taken from EL1 or EL0, and the Non-secure TTBCR.EAE is set to 1.
    long_format = FALSE;
    if route_to_monitor && !IsSecure() then
        long_format = TTBCR_S.EAE == '1' || PSTATE.EL == EL2 || TTBCR.EAE == '1';
    else
        long_format = TTBCR.EAE == '1';

    d_side = FALSE;
    if long_format then
        fsr = AArch32.FaultStatusLD(d_side, fault);
    else
        fsr = AArch32.FaultStatusSD(d_side, fault);

    if route_to_monitor then
        IFSR_S = fsr;
        IFAR_S = vaddress;
    else
        IFSR = fsr;
        IFAR = vaddress;

    return;
```

## Library pseudocode for aarch32/exceptions/aborts/AArch32.TakeDataAbortException

```
// AArch32.TakeDataAbortException()
// =====

AArch32.TakeDataAbortException(bits(32) vaddress, FaultRecord fault)
    route_to_monitor = HaveEL(EL3) && SCR.EA == '1' && IsExternalAbort(fault);
    route_to_hyp = (HaveEL(EL2) && !IsSecure() && PSTATE.EL IN {EL0, EL1} &&
        (HCR.TGE == '1' || IsSecondStage(fault) ||
        (HaveRASExt() && HCR2.TEA == '1' && IsExternalAbort(fault)) ||
        (IsDebugException(fault) && HDCR.TDE == '1')));
    bits(32) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x10;
    lr_offset = 8;

    if IsDebugException(fault) then DBGDSCRExt.MOE = fault.debugmoe;
    if route_to_monitor then
        AArch32.ReportDataAbort(route_to_monitor, fault, vaddress);
        AArch32.EnterMonitorMode(preferred_exception_return, lr_offset, vect_offset);
    elseif PSTATE.EL == EL2 || route_to_hyp then
        exception = AArch32.AbortSyndrome(Exception_DataAbort, fault, vaddress);
        if PSTATE.EL == EL2 then
            AArch32.EnterHypMode(exception, preferred_exception_return, vect_offset);
        else
            AArch32.EnterHypMode(exception, preferred_exception_return, 0x14);
    else
        AArch32.ReportDataAbort(route_to_monitor, fault, vaddress);
        AArch32.EnterMode(M32_Abort, preferred_exception_return, lr_offset, vect_offset);
```

## Library pseudocode for aarch32/exceptions/aborts/AArch32.TakePrefetchAbortException

```
// AArch32.TakePrefetchAbortException()
// =====

AArch32.TakePrefetchAbortException(bits(32) vaddress, FaultRecord fault)
    route_to_monitor = HaveEL(EL3) && SCR.EA == '1' && IsExternalAbort(fault);
    route_to_hyp = (HaveEL(EL2) && !IsSecure() && PSTATE.EL IN {EL0, EL1} &&
        (HCR.TGE == '1' || IsSecondStage(fault) ||
        (HaveRASExt() && HCR2.TEA == '1' && IsExternalAbort(fault)) ||
        (IsDebugException(fault) && HDCR.TDE == '1')));

    bits(32) preferred_exception_return = ThisInstrAddr();

    vect_offset = 0x0C;

    lr_offset = 4;

    if IsDebugException(fault) then DBGDSCRext.MOE = fault.debugmoe;
    if route_to_monitor then
        AArch32.ReportPrefetchAbort(route_to_monitor, fault, vaddress);
        AArch32.EnterMonitorMode(preferred_exception_return, lr_offset, vect_offset);
    elseif PSTATE.EL == EL2 || route_to_hyp then
        if fault.statuscode == Fault_Alignment then // PC Alignment fault
            exception = ExceptionSyndrome(Exception_PCAalignment);
            exception.vaddress = ThisInstrAddr();
        else
            exception = AArch32.AbortSyndrome(Exception_InstructionAbort, fault, vaddress);
        if PSTATE.EL == EL2 then
            AArch32.EnterHypMode(exception, preferred_exception_return, vect_offset);
        else
            AArch32.EnterHypMode(exception, preferred_exception_return, 0x14);
    else
        AArch32.ReportPrefetchAbort(route_to_monitor, fault, vaddress);
        AArch32.EnterMode(M32_Abort, preferred_exception_return, lr_offset, vect_offset);
```

## Library pseudocode for aarch32/exceptions/async/AArch32.TakePhysicalFIQException

```
// AArch32.TakePhysicalFIQException()
// =====

AArch32.TakePhysicalFIQException()

    // Check if routed to AArch64 state
    route_to_aarch64 = PSTATE.EL == EL0 && !ELUsingAArch32(EL1);
    if !route_to_aarch64 && EL2Enabled() && !ELUsingAArch32(EL2) then
        route_to_aarch64 = HCR_EL2.TGE == '1' || (HCR_EL2.FMO == '1' && !IsInHost());

    if !route_to_aarch64 && HaveEL(EL3) && !ELUsingAArch32(EL3) then
        route_to_aarch64 = SCR_EL3.FIQ == '1';

    if route_to_aarch64 then AArch64.TakePhysicalFIQException();
    route_to_monitor = HaveEL(EL3) && SCR.FIQ == '1';
    route_to_hyp = (PSTATE.EL IN {EL0, EL1} && EL2Enabled() &&
        (HCR.TGE == '1' || HCR.FMO == '1'));
    bits(32) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x1C;
    lr_offset = 4;
    if route_to_monitor then
        AArch32.EnterMonitorMode(preferred_exception_return, lr_offset, vect_offset);
    elseif PSTATE.EL == EL2 || route_to_hyp then
        exception = ExceptionSyndrome(Exception_FIQ);
        AArch32.EnterHypMode(exception, preferred_exception_return, vect_offset);
    else
        AArch32.EnterMode(M32_FIQ, preferred_exception_return, lr_offset, vect_offset);
```

## Library pseudocode for aarch32/exceptions/async/AArch32.TakePhysicalIRQException

```
// AArch32.TakePhysicalIRQException()
// =====
// Take an enabled physical IRQ exception.

AArch32.TakePhysicalIRQException()

    // Check if routed to AArch64 state
    route_to_aarch64 = PSTATE.EL == EL0 && !ELUsingAArch32(EL1);
    if !route_to_aarch64 && EL2Enabled() && !ELUsingAArch32(EL2) then
        route_to_aarch64 = HCR_EL2.TGE == '1' || (HCR_EL2.IMO == '1' && !IsInHost());
    if !route_to_aarch64 && HaveEL(EL3) && !ELUsingAArch32(EL3) then
        route_to_aarch64 = SCR_EL3.IRQ == '1';

    if route_to_aarch64 then AArch64.TakePhysicalIRQException();

    route_to_monitor = HaveEL(EL3) && SCR.IRQ == '1';
    route_to_hyp = (PSTATE.EL IN {EL0, EL1} && EL2Enabled() &&
        (HCR.TGE == '1' || HCR.IMO == '1'));
    bits(32) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x18;
    lr_offset = 4;
    if route_to_monitor then
        AArch32.EnterMonitorMode(preferred_exception_return, lr_offset, vect_offset);
    elsif PSTATE.EL == EL2 || route_to_hyp then
        exception = ExceptionSyndrome(Exception_IRQ);
        AArch32.EnterHypMode(exception, preferred_exception_return, vect_offset);
    else
        AArch32.EnterMode(M32_IRQ, preferred_exception_return, lr_offset, vect_offset);
```

## Library pseudocode for aarch32/exceptions/async/AArch32.TakePhysicalSErrorException

```
// AArch32.TakePhysicalSErrorException()
// =====

AArch32.TakePhysicalSErrorException(boolean parity, bit extflag, bits(2) pe_error_state,
                                     bits(25) full_syndrome)

    // Check if routed to AArch64 state
    route_to_aarch64 = PSTATE.EL == EL0 && !ELUsingAArch32\(EL1\);

    if !route_to_aarch64 && EL2Enabled\(\) && !ELUsingAArch32\(EL2\) then
        route_to_aarch64 = (HCR_EL2.TGE == '1' || (!IsInHost\(\) && HCR_EL2.AMO == '1'));
    if !route_to_aarch64 && HaveEL\(EL3\) && !ELUsingAArch32\(EL3\) then
        route_to_aarch64 = SCR_EL3.EA == '1';

    if route_to_aarch64 then
        AArch64.TakePhysicalSErrorException(full_syndrome);

    route_to_monitor = HaveEL\(EL3\) && SCR.EA == '1';
    route_to_hyp = (PSTATE.EL IN {EL0, EL1} && EL2Enabled\(\) &&
                   (HCR.TGE == '1' || HCR.AMO == '1'));
    bits(32) preferred_exception_return = ThisInstrAddr\(\);
    vect_offset = 0x10;
    lr_offset = 8;

    bits(2) target_el;
    if route_to_monitor then
        target_el = EL3;
    elsif PSTATE.EL == EL2 || route_to_hyp then
        target_el = EL2;
    else
        target_el = EL1;

    if IsSErrorEdgeTriggered(target_el, full_syndrome) then
        ClearPendingPhysicalSError\(\);

    fault = AsyncExternalAbort(parity, pe_error_state, extflag);
    vaddress = bits(32) UNKNOWN;

    case target_el of
        when EL3
            AArch32.ReportDataAbort(route_to_monitor, fault, vaddress);
            AArch32.EnterMonitorMode(preferred_exception_return, lr_offset, vect_offset);
        when EL2
            exception = AArch32.AbortSyndrome(Exception\_DataAbort, fault, vaddress);
            if PSTATE.EL == EL2 then
                AArch32.EnterHypMode(exception, preferred_exception_return, vect_offset);
            else
                AArch32.EnterHypMode(exception, preferred_exception_return, 0x14);
        when EL1
            AArch32.ReportDataAbort(route_to_monitor, fault, vaddress);
            AArch32.EnterMode\(M32\_Abort, preferred_exception_return, lr_offset, vect_offset);
        otherwise
            Unreachable\(\);
```

## Library pseudocode for aarch32/exceptions/async/AArch32.TakeVirtualFIQException

```
// AArch32.TakeVirtualFIQException()
// =====

AArch32.TakeVirtualFIQException()
    assert PSTATE.EL IN {EL0, EL1} && EL2Enabled();
    if ELUsingAArch32(EL2) then // Virtual IRQ enabled if TGE==0 and FM0==1
        assert HCR.TGE == '0' && HCR.FM0 == '1';
    else
        assert HCR_EL2.TGE == '0' && HCR_EL2.FM0 == '1';
    // Check if routed to AArch64 state
    if PSTATE.EL == EL0 && !ELUsingAArch32(EL1) then AArch64.TakeVirtualFIQException();

    bits(32) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x1C;
    lr_offset = 4;

    AArch32.EnterMode(M32_FIQ, preferred_exception_return, lr_offset, vect_offset);
```

## Library pseudocode for aarch32/exceptions/async/AArch32.TakeVirtualIRQException

```
// AArch32.TakeVirtualIRQException()
// =====

AArch32.TakeVirtualIRQException()
    assert PSTATE.EL IN {EL0, EL1} && EL2Enabled();

    if ELUsingAArch32(EL2) then // Virtual IRQs enabled if TGE==0 and IM0==1
        assert HCR.TGE == '0' && HCR.IM0 == '1';
    else
        assert HCR_EL2.TGE == '0' && HCR_EL2.IM0 == '1';

    // Check if routed to AArch64 state
    if PSTATE.EL == EL0 && !ELUsingAArch32(EL1) then AArch64.TakeVirtualIRQException();

    bits(32) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x18;
    lr_offset = 4;

    AArch32.EnterMode(M32_IRQ, preferred_exception_return, lr_offset, vect_offset);
```



## Library pseudocode for aarch32/exceptions/async/AArch32.TakeVirtualErrorException

```
// AArch32.TakeVirtualErrorException()
// =====

AArch32.TakeVirtualErrorException(bit extflag, bits(2) pe_error_state, bits(25) full_syndrome)

    assert PSTATE.EL IN {EL0, EL1} && EL2Enabled();
    if ELUsingAArch32(EL2) then // Virtual SError enabled if TGE==0 and AM0==1
        assert HCR.TGE == '0' && HCR.AM0 == '1';
    else
        assert HCR_EL2.TGE == '0' && HCR_EL2.AM0 == '1';
    // Check if routed to AArch64 state
    if PSTATE.EL == EL0 && !ELUsingAArch32(EL1) then AArch64.TakeVirtualErrorException(full_syndrome);

    route_to_monitor = FALSE;

    bits(32) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x10;
    lr_offset = 8;

    vaddress = bits(32) UNKNOWN;
    parity = FALSE;
    if HaveRASExt() then
        if ELUsingAArch32(EL2) then
            fault = AsyncExternalAbort(FALSE, VDFSR.AET, VDFSR.ExT);
        else
            fault = AsyncExternalAbort(FALSE, VESR_EL2.AET, VESR_EL2.ExT);
    else
        fault = AsyncExternalAbort(parity, pe_error_state, extflag);

    ClearPendingVirtualSError();
    AArch32.ReportDataAbort(route_to_monitor, fault, vaddress);
    AArch32.EnterMode(M32_Abort, preferred_exception_return, lr_offset, vect_offset);
```

## Library pseudocode for aarch32/exceptions/debug/AArch32.SoftwareBreakpoint

```
// AArch32.SoftwareBreakpoint()
// =====

AArch32.SoftwareBreakpoint(bits(16) immediate)

    if (EL2Enabled() && !ELUsingAArch32(EL2) &&
        (HCR_EL2.TGE == '1' || MDCR_EL2.TDE == '1')) || !ELUsingAArch32(EL1) then
        AArch64.SoftwareBreakpoint(immediate);
    vaddress = bits(32) UNKNOWN;
    acctype = AccType_IFETCH; // Take as a Prefetch Abort
    iswrite = FALSE;
    entry = DebugException_BKPT;

    fault = AArch32.DebugFault(acctype, iswrite, entry);
    AArch32.Abort(vaddress, fault);
```

## Library pseudocode for aarch32/exceptions/debug/DebugException

```
constant bits(4) DebugException_Breakpoint = '0001';
constant bits(4) DebugException_BKPT      = '0011';
constant bits(4) DebugException_VectorCatch = '0101';
constant bits(4) DebugException_Watchpoint = '1010';
```

## Library pseudocode for aarch32/exceptions/exceptions/ AArch32.CheckAdvSIMDOrFPRegisterTraps

```
// AArch32.CheckAdvSIMDOrFPRegisterTraps()
// =====
// Check if an instruction that accesses an Advanced SIMD and
// floating-point System register is trapped by an appropriate HCR.TIDx
// ID group trap control.

AArch32.CheckAdvSIMDOrFPRegisterTraps(bits(4) reg)

    if PSTATE.EL == EL1 && EL2Enabled() then
        tid0 = if ELUsingAArch32(EL2) then HCR.TID0 else HCR_EL2.TID0;
        tid3 = if ELUsingAArch32(EL2) then HCR.TID3 else HCR_EL2.TID3;

        if (tid0 == '1' && reg == '0000') // FPSID
            || (tid3 == '1' && reg IN {'0101', '0110', '0111'}) then // MVFRx
                if ELUsingAArch32(EL2) then
                    AArch32.SystemAccessTrap(M32_Hyp, 0x8); // Exception_AdvSIMDFPAccessTrap
                else
                    AArch64.AArch32SystemAccessTrap(EL2, 0x8); // Exception_AdvSIMDFPAccessTrap
```

## Library pseudocode for aarch32/exceptions/exceptions/AArch32.ExceptionClass

```
// AArch32.ExceptionClass()
// =====
// Returns the Exception Class and Instruction Length fields to be reported in HSR

(integer,bit) AArch32.ExceptionClass(Exception exceptype)

    il_is_valid = TRUE;

    case exceptype of
        when Exception_Uncategorized      ec = 0x00; il_is_valid = FALSE;
        when Exception_WFxTrap            ec = 0x01;
        when Exception_CP15RITrap         ec = 0x03;
        when Exception_CP15RRTTrap        ec = 0x04;
        when Exception_CP14RTTrap         ec = 0x05;
        when Exception_CP14DTTrap         ec = 0x06;
        when Exception_AdvSIMDFPAccessTrap ec = 0x07;
        when Exception_FPIDTrap           ec = 0x08;
        when Exception_PACTrap            ec = 0x09;
        when Exception_LDST64BTrap        ec = 0x0A;
        when Exception_CP14RRTTrap        ec = 0x0C;
        when Exception_BranchTarget       ec = 0x0D;
        when Exception_IllegalState       ec = 0x0E; il_is_valid = FALSE;
        when Exception_SupervisorCall     ec = 0x11;
        when Exception_HypervisorCall     ec = 0x12;
        when Exception_MonitorCall        ec = 0x13;
        when Exception_InstructionAbort   ec = 0x20; il_is_valid = FALSE;
        when Exception_PCAlignment        ec = 0x22; il_is_valid = FALSE;
        when Exception_DataAbort          ec = 0x24;
        when Exception_NV2DataAbort        ec = 0x25;
        when Exception_FPtrappedException ec = 0x28;
        otherwise                          Unreachable();

    if ec IN {0x20,0x24} && PSTATE.EL == EL2 then
        ec = ec + 1;

    if il_is_valid then
        il = if ThisInstrLength() == 32 then '1' else '0';
    else
        il = '1';

    return (ec,il);
```

## Library pseudocode for aarch32/exceptions/exceptions/AArch32.GeneralExceptionsToAArch64

```
// AArch32.GeneralExceptionsToAArch64()
// =====
// Returns TRUE if exceptions normally routed to EL1 are being handled at an Exception
// level using AArch64, because either EL1 is using AArch64 or TGE is in force and EL2
// is using AArch64.

boolean AArch32.GeneralExceptionsToAArch64()
    return ((PSTATE.EL == EL0 && !ELUsingAArch32\(EL1\)) ||
            (EL2Enabled\(\) && !ELUsingAArch32\(EL2\) && HCR_EL2.TGE == '1'));
```

## Library pseudocode for aarch32/exceptions/exceptions/AArch32.ReportHypEntry

```
// AArch32.ReportHypEntry()
// =====
// Report syndrome information to Hyp mode registers.

AArch32.ReportHypEntry(ExceptionRecord exception)

    Exception exceptype = exception.exceptype;

    (ec,il) = AArch32.ExceptionClass(exceptype);
    iss = exception.syndrome;

    // IL is not valid for Data Abort exceptions without valid instruction syndrome information
    if ec IN {0x24,0x25} && iss<24> == '0' then
        il = '1';

    HSR = ec<5:0>:il:iss;

    if exceptype IN {Exception\_InstructionAbort, Exception\_PCAlignment} then
        HIFAR = exception.vaddress<31:0>;
        HDFAR = bits(32) UNKNOWN;
    elseif exceptype == Exception\_DataAbort then
        HIFAR = bits(32) UNKNOWN;
        HDFAR = exception.vaddress<31:0>;

    if exception.ipavalid then
        HPFAR<31:4> = exception.ipaddress<39:12>;
    else
        HPFAR<31:4> = bits(28) UNKNOWN;

    return;
```

## Library pseudocode for aarch32/exceptions/exceptions/AArch32.ResetControlRegisters

```
// Resets System registers and memory-mapped control registers that have architecturally-defined
// reset values to those values.
AArch32.ResetControlRegisters(boolean cold_reset);
```

## Library pseudocode for aarch32/exceptions/exceptions/AArch32.TakeReset

```
// AArch32.TakeReset()
// =====
// Reset into AArch32 state

AArch32.TakeReset(boolean cold_reset)
    assert HighestELUsingAArch32\(\);

    // Enter the highest implemented Exception level in AArch32 state
    if HaveEL\(EL3\) then
        AArch32.WriteMode\(M32\_Svc\);
        SCR.NS = '0'; // Secure state
    elseif HaveEL\(EL2\) then
        AArch32.WriteMode\(M32\_Hyp\);
    else
        AArch32.WriteMode\(M32\_Svc\);

    // Reset the CP14 and CP15 registers and other system components
    AArch32.ResetControlRegisters(cold_reset);
    FPEXC.EN = '0';

    // Reset all other PSTATE fields, including instruction set and endianness according to the
    // SCTLR values produced by the above call to ResetControlRegisters()
    PSTATE.<A,I,F> = '111'; // All asynchronous exceptions masked
    PSTATE.IT = '00000000'; // IT block state reset
    PSTATE.T = SCTLR.TE; // Instruction set: TE=0: A32, TE=1: T32. PSTATE.J is RES0.
    PSTATE.E = SCTLR.EE; // Endianness: EE=0: little-endian, EE=1: big-endian
    PSTATE.IL = '0'; // Clear Illegal Execution state bit

    // All registers, bits and fields not reset by the above pseudocode or by the BranchTo() call
    // below are UNKNOWN bitstrings after reset. In particular, the return information registers
    // R14 or ELR_hyp and SPSR have UNKNOWN values, so that it
    // is impossible to return from a reset in an architecturally defined way.
    AArch32.ResetGeneralRegisters\(\);
    AArch32.ResetSIMDFPRegisters\(\);
    AArch32.ResetSpecialRegisters\(\);
    ResetExternalDebugRegisters(cold_reset);

    bits(32) rv; // IMPLEMENTATION DEFINED reset vector

    if HaveEL\(EL3\) then
        if MVBAR<0> == '1' then // Reset vector in MVBAR
            rv = MVBAR<31:1>:'0';
        else
            rv = bits(32) IMPLEMENTATION_DEFINED "reset vector address";
    else
        rv = RVBAR<31:1>:'0';

    // The reset vector must be correctly aligned
    assert rv<0> == '0' && (PSTATE.T == '1' || rv<1> == '0');

    boolean branch_conditional = FALSE;
    BranchTo(rv, BranchType\_RESET, branch_conditional);
```

## Library pseudocode for aarch32/exceptions/exceptions/ExcVectorBase

```
// ExcVectorBase()
// =====

bits(32) ExcVectorBase()
    if SCTLR.V == '1' then // Hivecs selected, base = 0xFFFF0000
        return Ones(16):Zeros(16);
    else
        return VBAR<31:5>:Zeros(5);
```

## Library pseudocode for aarch32/exceptions/ieeefp/AArch32.FPTrappedException

```
// AArch32.FPTrappedException()
// =====

AArch32.FPTrappedException(bits(8) accumulated_exceptions)
    if AArch32.GeneralExceptionsToAArch64\(\) then
        is_ase = FALSE;
        element = 0;
        AArch64.FPTrappedException(is_ase, accumulated_exceptions);
    FPEXC.DEX    = '1';
    FPEXC.TFV    = '1';
    FPEXC<7,4:0> = accumulated_exceptions<7,4:0>;           // IDF,IXF,UFF,OFF,DZF,I0F
    FPEXC<10:8>  = '111';                                   // VECITR is RES1

    AArch32.TakeUndefInstrException();
```

## Library pseudocode for aarch32/exceptions/syscalls/AArch32.CallHypervisor

```
// AArch32.CallHypervisor()
// =====
// Performs a HVC call

AArch32.CallHypervisor(bits(16) immediate)
    assert HaveEL\(EL2\);

    if !ELUsingAArch32\(EL2\) then
        AArch64.CallHypervisor(immediate);
    else
        AArch32.TakeHVCEException(immediate);
```

## Library pseudocode for aarch32/exceptions/syscalls/AArch32.CallSupervisor

```
// AArch32.CallSupervisor()
// =====
// Calls the Supervisor

AArch32.CallSupervisor(bits(16) immediate)

    if AArch32.CurrentCond\(\) != '1110' then
        immediate = bits(16) UNKNOWN;
    if AArch32.GeneralExceptionsToAArch64\(\) then
        AArch64.CallSupervisor(immediate);
    else
        AArch32.TakeSVCEException(immediate);
```

## Library pseudocode for aarch32/exceptions/syscalls/AArch32.TakeHVCEException

```
// AArch32.TakeHVCEException()
// =====

AArch32.TakeHVCEException(bits(16) immediate)
    assert HaveEL\(EL2\) && ELUsingAArch32\(EL2\);

    AArch32.ITAdvance();
    SSAdvance();
    bits(32) preferred_exception_return = NextInstrAddr();
    vect_offset = 0x08;

    exception = ExceptionSyndrome\(Exception\_HypervisorCall\);
    exception.syndrome<15:0> = immediate;

    if PSTATE.EL == EL2 then
        AArch32.EnterHypMode(exception, preferred_exception_return, vect_offset);
    else
        AArch32.EnterHypMode(exception, preferred_exception_return, 0x14);
```

## Library pseudocode for aarch32/exceptions/syscalls/AArch32.TakeSMCException

```
// AArch32.TakeSMCException()
// =====

AArch32.TakeSMCException()
    assert HaveEL(EL3) && ELUsingAArch32(EL3);
    AArch32.ITAdvance();
    SSAdvance();
    bits(32) preferred_exception_return = NextInstrAddr();
    vect_offset = 0x08;
    lr_offset = 0;

    AArch32.EnterMonitorMode(preferred_exception_return, lr_offset, vect_offset);
```

## Library pseudocode for aarch32/exceptions/syscalls/AArch32.TakeSVCException

```
// AArch32.TakeSVCException()
// =====

AArch32.TakeSVCException(bits(16) immediate)

    AArch32.ITAdvance();
    SSAdvance();
    route_to_hyp = PSTATE.EL == EL0 && EL2Enabled() && HCR.TGE == '1';

    bits(32) preferred_exception_return = NextInstrAddr();
    vect_offset = 0x08;
    lr_offset = 0;

    if PSTATE.EL == EL2 || route_to_hyp then
        exception = ExceptionSyndrome(Exception_SupervisorCall);
        exception.syndrome<15:0> = immediate;
        if PSTATE.EL == EL2 then
            AArch32.EnterHypMode(exception, preferred_exception_return, vect_offset);
        else
            AArch32.EnterHypMode(exception, preferred_exception_return, 0x14);
    else
        AArch32.EnterMode(M32_Svc, preferred_exception_return, lr_offset, vect_offset);
```

## Library pseudocode for aarch32/exceptions/takeexception/AArch32.EnterHypMode

```
// AArch32.EnterHypMode()
// =====
// Take an exception to Hyp mode.

AArch32.EnterHypMode(ExceptionRecord exception, bits(32) preferred_exception_return,
                    integer vect_offset)
    SynchronizeContext();
    assert HaveEL(EL2) && !IsSecure() && ELUsingAArch32(EL2);

    bits(32) spsr = GetPSRFromPSTATE(AArch32_NonDebugState);
    if !(exception.exceptype IN {Exception_IRQ, Exception_FIQ}) then
        AArch32.ReportHypEntry(exception);
    AArch32.WriteMode(M32_Hyp);
    SPSR[] = spsr;
    ELR_hyp = preferred_exception_return;
    PSTATE.T = HSCTLR.TE; // PSTATE.J is RES0
    PSTATE.SS = '0';
    if !HaveEL(EL3) || SCR_GEN[].EA == '0' then PSTATE.A = '1';
    if !HaveEL(EL3) || SCR_GEN[].IRQ == '0' then PSTATE.I = '1';
    if !HaveEL(EL3) || SCR_GEN[].FIQ == '0' then PSTATE.F = '1';
    PSTATE.E = HSCTLR.EE;
    PSTATE.IL = '0';
    PSTATE.IT = '00000000';
    if HaveSSBSExt() then PSTATE.SSBS = HSCTLR.DSSBS;
    boolean branch_conditional = FALSE;
    BranchTo(HVBAR<31:5>:vect_offset<4:0>, BranchType_EXCEPTION, branch_conditional);

    EndOfInstruction();
```

## Library pseudocode for aarch32/exceptions/takeexception/AArch32.EnterMode

```
// AArch32.EnterMode()
// =====
// Take an exception to a mode other than Monitor and Hyp mode.

AArch32.EnterMode(bits(5) target_mode, bits(32) preferred_exception_return, integer lr_offset,
                 integer vect_offset)
    SynchronizeContext();
    assert ELUsingAArch32(EL1) && PSTATE.EL != EL2;

    bits(32) spsr = GetPSRFromPSTATE(AArch32_NonDebugState);
    if PSTATE.M == M32_Monitor then SCR.NS = '0';
    AArch32.WriteMode(target_mode);
    SPSR[] = spsr;
    R[14] = preferred_exception_return + lr_offset;
    PSTATE.T = SCTLR.TE; // PSTATE.J is RES0
    PSTATE.SS = '0';
    if target_mode == M32_FIQ then
        PSTATE.<A,I,F> = '111';
    elsif target_mode IN {M32_Abort, M32_IRQ} then
        PSTATE.<A,I> = '11';
    else
        PSTATE.I = '1';
    PSTATE.E = SCTLR.EE;
    PSTATE.IL = '0';
    PSTATE.IT = '00000000';
    if HavePANExt() && SCTLR.SPAN == '0' then PSTATE.PAN = '1';
    if HaveSSBSExt() then PSTATE.SSBS = SCTLR.DSSBS;
    boolean branch_conditional = FALSE;
    BranchTo(ExcVectorBase()<31:5>:vect_offset<4:0>, BranchType_EXCEPTION, branch_conditional);

    EndOfInstruction();
```

## Library pseudocode for aarch32/exceptions/takeexception/AArch32.EnterMonitorMode

```
// AArch32.EnterMonitorMode()
// =====
// Take an exception to Monitor mode.

AArch32.EnterMonitorMode(bits(32) preferred_exception_return, integer lr_offset,
                        integer vect_offset)
    SynchronizeContext();
    assert HaveEL(EL3) && ELUsingAArch32(EL3);
    from_secure = IsSecure();
    bits(32) spsr = GetPSRFromPSTATE(AArch32_NonDebugState);
    if PSTATE.M == M32_Monitor then SCR.NS = '0';
    AArch32.WriteMode(M32_Monitor);
    SPSR[] = spsr;
    R[14] = preferred_exception_return + lr_offset;
    PSTATE.T = SCTL.R.TE; // PSTATE.J is RES0
    PSTATE.SS = '0';
    PSTATE.<A,I,F> = '111';
    PSTATE.E = SCTL.R.EE;
    PSTATE.IL = '0';
    PSTATE.IT = '00000000';
    if HavePANExt() then
        if !from_secure then
            PSTATE.PAN = '0';
        elsif SCTL.R.SPAN == '0' then
            PSTATE.PAN = '1';
    if HaveSSBSExt() then PSTATE.SSBS = SCTL.R.DSSBS;
    boolean branch_conditional = FALSE;
    BranchTo(MVBAR<31:5>:vect_offset<4:0>, BranchType_EXCEPTION, branch_conditional);

    EndOfInstruction();
```



## Library pseudocode for aarch32/exceptions/traps/AArch32.CheckAdvSIMDOrFPEEnabled

```
// AArch32.CheckAdvSIMDOrFPEEnabled()
// =====
// Check against CPACR, FPEXC, HCPTR, NSACR, and CPTR_EL3.

AArch32.CheckAdvSIMDOrFPEEnabled(boolean fpexc_check, boolean advsimd)
    if PSTATE.EL == EL0 && (!HaveEL(EL2) || (!ELUsingAArch32(EL2) && HCR_EL2.TGE == '0')) && !ELUsingAArch32(EL2)
        // The PE behaves as if FPEXC.EN is 1
        AArch64.CheckFPAAdvSIMDEnabled();
    elsif PSTATE.EL == EL0 && HaveEL(EL2) && !ELUsingAArch32(EL2) && HCR_EL2.TGE == '1' && !ELUsingAArch32(EL2)
        if fpexc_check && HCR_EL2.RW == '0' then
            fpexc_en = bits(1) IMPLEMENTATION_DEFINED "FPEXC.EN value when TGE==1 and RW==0";
            if fpexc_en == '0' then UNDEFINED;
            AArch64.CheckFPAAdvSIMDEnabled();
        else
            cpacr_asedis = CPACR.ASEDIS;
            cpacr_cp10 = CPACR.cp10;

            if HaveEL(EL3) && ELUsingAArch32(EL3) && !IsSecure() then
                // Check if access disabled in NSACR
                if NSACR.NSASEDIS == '1' then cpacr_asedis = '1';
                if NSACR.cp10 == '0' then cpacr_cp10 = '00';

            if PSTATE.EL != EL2 then
                // Check if Advanced SIMD disabled in CPACR
                if advsimd && cpacr_asedis == '1' then UNDEFINED;

                // Check if access disabled in CPACR
                case cpacr_cp10 of
                    when '00' disabled = TRUE;
                    when '01' disabled = PSTATE.EL == EL0;
                    when '10' disabled = ConstrainUnpredictableBool(Unpredictable_RESCPACR);
                    when '11' disabled = FALSE;
                if disabled then UNDEFINED;

            // If required, check FPEXC enabled bit.
            if fpexc_check && FPEXC.EN == '0' then UNDEFINED;

            AArch32.CheckFPAAdvSIMDTrap(advsimd);    // Also check against HCPTR and CPTR_EL3
```

## Library pseudocode for aarch32/exceptions/traps/AArch32.CheckFPAdvSIMDTrap

```
// AArch32.CheckFPAdvSIMDTrap()
// =====
// Check against CPTR_EL2 and CPTR_EL3.

AArch32.CheckFPAdvSIMDTrap(boolean advsimd)
  if EL2Enabled\(\) && !ELUsingAArch32\(EL2\) then
    AArch64.CheckFPAdvSIMDTrap\(\);
  else
    if HaveEL\(EL2\) && !IsSecure\(\) then
      hcptr_tase = HCPTR.TASE;
      hcptr_cp10 = HCPTR.TCP10;

      if HaveEL\(EL3\) && ELUsingAArch32\(EL3\) && !IsSecure\(\) then
        // Check if access disabled in NSACR
        if NSACR.NSASEDIS == '1' then hcptr_tase = '1';
        if NSACR.cp10 == '0' then hcptr_cp10 = '1';

        // Check if access disabled in HCPTR
        if (advsimd && hcptr_tase == '1') || hcptr_cp10 == '1' then
          exception = ExceptionSyndrome\(Exception\_AdvSIMDFPAccessTrap\);
          exception.syndrome<24:20> = ConditionSyndrome\(\);

          if advsimd then
            exception.syndrome<5> = '1';
          else
            exception.syndrome<5> = '0';
            exception.syndrome<3:0> = '1010';           // coproc field, always 0xA

          if PSTATE.EL == EL2 then
            AArch32.TakeUndefInstrException\(exception\);
          else
            AArch32.TakeHypTrapException\(exception\);

    if HaveEL\(EL3\) && !ELUsingAArch32\(EL3\) then
      // Check if access disabled in CPTR_EL3
      if CPTR_EL3.TFP == '1' then AArch64.AdvSIMDFPAccessTrap\(EL3\);

  return;
```

## Library pseudocode for aarch32/exceptions/traps/AArch32.CheckForSMCUndefOrTrap

```
// AArch32.CheckForSMCUndefOrTrap()
// =====
// Check for UNDEFINED or trap on SMC instruction

AArch32.CheckForSMCUndefOrTrap()
  if !HaveEL\(EL3\) || PSTATE.EL == EL0 then
    UNDEFINED;

  if EL2Enabled\(\) && !ELUsingAArch32\(EL2\) then
    AArch64.CheckForSMCUndefOrTrap\(Zeros\(16\)\);
  else
    route_to_hyp = HaveEL\(EL2\) && !IsSecure\(\) && PSTATE.EL == EL1 && HCR.TSC == '1';
    if route_to_hyp then
      exception = ExceptionSyndrome\(Exception\_MonitorCall\);
      AArch32.TakeHypTrapException\(exception\);
```

## Library pseudocode for aarch32/exceptions/traps/AArch32.CheckForSVCTrap

```
// AArch32.CheckForSVCTrap()
// =====
// Check for trap on SVC instruction

AArch32.CheckForSVCTrap(bits(16) immediate)
    if HaveFGTExt() then
        route_to_el2 = FALSE;
        if PSTATE.EL == EL0 then
            route_to_el2 = (!ELUsingAArch32(EL1) && EL2Enabled() && HFGITR_EL2.SVC_EL0 == '1' &&
                (HCR_EL2.<E2H, TGE> != '11' && (!HaveEL(EL3) || SCR_EL3.FGTEn == '1')));

        if route_to_el2 then
            exception = ExceptionSyndrome(Exception_SupervisorCall);
            exception.syndrome<15:0> = immediate;
            bits(64) preferred_exception_return = ThisInstrAddr();
            vect_offset = 0x0;

            AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch32/exceptions/traps/AArch32.CheckForWFXTrap

```
// AArch32.CheckForWFXTrap()
// =====
// Check for trap on WFE or WFI instruction

AArch32.CheckForWFXTrap(bits(2) target_el, WFXType wfxtype)
    assert HaveEL(target_el);

    // Check for routing to AArch64
    if !ELUsingAArch32(target_el) then
        AArch64.CheckForWFXTrap(target_el, wfxtype);
        return;

    boolean is_wfe = wfxtype IN {WFXType_WFE, WFXType_WFET};
    case target_el of
        when EL1
            trap = (if is_wfe then SCTLR.nTWE else SCTLR.nTWI) == '0';
        when EL2
            trap = (if is_wfe then HCR.TWE else HCR.TWI) == '1';
        when EL3
            trap = (if is_wfe then SCR.TWE else SCR.TWI) == '1';

    if trap then
        if target_el == EL1 && EL2Enabled() && !ELUsingAArch32(EL2) && HCR_EL2.TGE == '1' then
            AArch64.WFXTrap(wfxtype, target_el);

        if target_el == EL3 then
            AArch32.TakeMonitorTrapException();
        elsif target_el == EL2 then
            exception = ExceptionSyndrome(Exception_WFXTrap);
            exception.syndrome<24:20> = ConditionSyndrome();

            case wfxtype of
                when WFXType_WFI
                    exception.syndrome<0> = '0';
                when WFXType_WFE
                    exception.syndrome<0> = '1';

            AArch32.TakeHypTrapException(exception);
        else
            AArch32.TakeUndefInstrException();
```

## Library pseudocode for aarch32/exceptions/traps/AArch32.CheckITEnabled

```
// AArch32.CheckITEnabled()
// =====
// Check whether the T32 IT instruction is disabled.

AArch32.CheckITEnabled(bits(4) mask)
    if PSTATE.EL == EL2 then
        it_disabled = HSCTLR.ITD;
    else
        it_disabled = (if ELUsingAArch32(EL1) then SCTLR.ITD else SCTLR[.].ITD);
    if it_disabled == '1' then
        if mask != '1000' then UNDEFINED;

    // Otherwise whether the IT block is allowed depends on hw1 of the next instruction.
    next_instr = AArch32.MemSingle[NextInstrAddr(), 2, AccType_IFETCH, TRUE];

    if next_instr IN {'11xxxxxxxxxxxx', '1011xxxxxxxxxxxx', '10100xxxxxxxxxxxx',
                     '01001xxxxxxxxxxxx', '010001xxx1111xxx', '010001xx1xxxx111'} then
        // It is IMPLEMENTATION DEFINED whether the Undefined Instruction exception is
        // taken on the IT instruction or the next instruction. This is not reflected in
        // the pseudocode, which always takes the exception on the IT instruction. This
        // also does not take into account cases where the next instruction is UNPREDICTABLE.
        UNDEFINED;

    return;
```

## Library pseudocode for aarch32/exceptions/traps/AArch32.CheckIllegalState

```
// AArch32.CheckIllegalState()
// =====
// Check PSTATE.IL bit and generate Illegal Execution state exception if set.

AArch32.CheckIllegalState()
    if AArch32.GeneralExceptionsToAArch64() then
        AArch64.CheckIllegalState();
    elsif PSTATE.IL == '1' then
        route_to_hyp = PSTATE.EL == EL0 && EL2Enabled() && HCR.TGE == '1';

        bits(32) preferred_exception_return = ThisInstrAddr();
        vect_offset = 0x04;

        if PSTATE.EL == EL2 || route_to_hyp then
            exception = ExceptionSyndrome(Exception_IllegalState);
            if PSTATE.EL == EL2 then
                AArch32.EnterHypMode(exception, preferred_exception_return, vect_offset);
            else
                AArch32.EnterHypMode(exception, preferred_exception_return, 0x14);
        else
            AArch32.TakeUndefInstrException();
```

## Library pseudocode for aarch32/exceptions/traps/AArch32.CheckSETENDEnabled

```
// AArch32.CheckSETENDEnabled()
// =====
// Check whether the AArch32 SETEND instruction is disabled.

AArch32.CheckSETENDEnabled()
    if PSTATE.EL == EL2 then
        setend_disabled = HSCTLR.SED;
    else
        setend_disabled = (if ELUsingAArch32(EL1) then SCTLR.SED else SCTLR[.].SED);
    if setend_disabled == '1' then
        UNDEFINED;

    return;
```

## Library pseudocode for aarch32/exceptions/traps/AArch32.SystemAccessTrap

```
// AArch32.SystemAccessTrap()
// =====
// Trapped system register access.

AArch32.SystemAccessTrap(bits(5) mode, integer ec)
    (valid, target_el) = ELFromM32(mode);
    assert valid && HaveEL(target_el) && target_el != EL0 && UInt(target_el) >= UInt(PSTATE.EL);

    if target_el == EL2 then
        exception = AArch32.SystemAccessTrapSyndrome(ThisInstr(), ec);
        AArch32.TakeHypTrapException(exception);
    else
        AArch32.TakeUndefInstrException();
```

## Library pseudocode for aarch32/exceptions/traps/AArch32.SystemAccessTrapSyndrome

```
// AArch32.SystemAccessTrapSyndrome()
// =====
// Returns the syndrome information for traps on AArch32 MCR, MCRR, MRC, MRRC, and VMRS, VMSR instructions
// other than traps that are due to HCPTR or CPACR.

ExceptionRecord AArch32.SystemAccessTrapSyndrome(bits(32) instr, integer ec)
    ExceptionRecord exception;

    case ec of
        when 0x0    exception = ExceptionSyndrome(Exception_Uncategorized);
        when 0x3    exception = ExceptionSyndrome(Exception_CP15RTTTrap);
        when 0x4    exception = ExceptionSyndrome(Exception_CP15RRTTrap);
        when 0x5    exception = ExceptionSyndrome(Exception_CP14RTTTrap);
        when 0x6    exception = ExceptionSyndrome(Exception_CP14DTTTrap);
        when 0x7    exception = ExceptionSyndrome(Exception_AdvSIMDFPAccessTrap);
        when 0x8    exception = ExceptionSyndrome(Exception_FPIDTrap);
        when 0xC    exception = ExceptionSyndrome(Exception_CP14RRTTrap);
        otherwise   Unreachable();

    bits(20) iss = Zeros();

    if exception.exceptype IN {Exception_FPIDTrap, Exception_CP14RTTTrap, Exception_CP15RTTTrap} then
        // Trapped MRC/MCR, VMRS on FPSID
        iss<13:10> = instr<19:16>;          // CRn, Reg in case of VMRS
        iss<8:5>   = instr<15:12>;          // Rt
        iss<9>     = '0';                   // RES0

        if exception.exceptype != Exception_FPIDTrap then // When trap is not for VMRS
            iss<19:17> = instr<7:5>;          // opc2
            iss<16:14> = instr<23:21>;        // opc1
            iss<4:1>   = instr<3:0>;          // CRm
        else //VMRS Access
            iss<19:17> = '000';              //opc2 - Hardcoded for VMRS
            iss<16:14> = '111';              //opc1 - Hardcoded for VMRS
            iss<4:1>   = '0000';             //CRm - Hardcoded for VMRS
        elsif exception.exceptype IN {Exception_CP14RRTTrap, Exception_AdvSIMDFPAccessTrap, Exception_CP15RRTTrap} then
            // Trapped MRRC/MCRR, VMRS/VMSR
            iss<19:16> = instr<7:4>;          // opc1
            iss<13:10> = instr<19:16>;        // Rt2
            iss<8:5>   = instr<15:12>;        // Rt
            iss<4:1>   = instr<3:0>;          // CRm
        elsif exception.exceptype == Exception_CP14DTTTrap then
            // Trapped LDC/STC
            iss<19:12> = instr<7:0>;          // imm8
            iss<4>     = instr<23>;           // U
            iss<2:1>   = instr<24,21>;        // P,W
            if instr<19:16> == '1111' then // Rn==15, LDC(Literal addressing)/STC
                iss<8:5> = bits(4) UNKNOWN;
                iss<3>   = '1';
            elsif exception.exceptype == Exception_Uncategorized then
                // Trapped for unknown reason
                iss<8:5> = instr<19:16>;      // Rn
                iss<3>   = '0';

            iss<0> = instr<20>;                // Direction

        exception.syndrome<24:20> = ConditionSyndrome();
        exception.syndrome<19:0>  = iss;

    return exception;
```

## Library pseudocode for aarch32/exceptions/traps/AArch32.TakeHypTrapException

```
// AArch32.TakeHypTrapException()
// =====
// Exceptions routed to Hyp mode as a Hyp Trap exception.

AArch32.TakeHypTrapException(integer ec)
    exception = AArch32.SystemAccessTrapSyndrome(ThisInstr(), ec);
    AArch32.TakeHypTrapException(exception);

// AArch32.TakeHypTrapException()
// =====
// Exceptions routed to Hyp mode as a Hyp Trap exception.

AArch32.TakeHypTrapException(ExceptionRecord exception)
    assert HaveEL(EL2) && !IsSecure() && ELUsingAArch32(EL2);

    bits(32) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x14;

    AArch32.EnterHypMode(exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch32/exceptions/traps/AArch32.TakeMonitorTrapException

```
// AArch32.TakeMonitorTrapException()
// =====
// Exceptions routed to Monitor mode as a Monitor Trap exception.

AArch32.TakeMonitorTrapException()
    assert HaveEL(EL3) && ELUsingAArch32(EL3);

    bits(32) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x04;
    lr_offset = if CurrentInstrSet() == InstrSet_A32 then 4 else 2;

    AArch32.EnterMonitorMode(preferred_exception_return, lr_offset, vect_offset);
```

## Library pseudocode for aarch32/exceptions/traps/AArch32.TakeUndefInstrException

```
// AArch32.TakeUndefInstrException()
// =====

AArch32.TakeUndefInstrException()
    exception = ExceptionSyndrome(Exception_Uncategorized);
    AArch32.TakeUndefInstrException(exception);

// AArch32.TakeUndefInstrException()
// =====

AArch32.TakeUndefInstrException(ExceptionRecord exception)

    route_to_hyp = PSTATE.EL == EL0 && EL2Enabled() && HCR.TGE == '1';
    bits(32) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x04;
    lr_offset = if CurrentInstrSet() == InstrSet_A32 then 4 else 2;

    if PSTATE.EL == EL2 then
        AArch32.EnterHypMode(exception, preferred_exception_return, vect_offset);
    elsif route_to_hyp then
        AArch32.EnterHypMode(exception, preferred_exception_return, 0x14);
    else
        AArch32.EnterMode(M32_Undef, preferred_exception_return, lr_offset, vect_offset);
```

## Library pseudocode for aarch32/exceptions/traps/AArch32.UndefinedFault

```
// AArch32.UndefinedFault()
// =====

AArch32.UndefinedFault()

    if AArch32.GeneralExceptionsToAArch64() then AArch64.UndefinedFault();
    AArch32.TakeUndefInstrException();
```

## Library pseudocode for aarch32/functions/aborts/AArch32.DomainValid

```
// AArch32.DomainValid()
// =====
// Returns TRUE if the Domain is valid for a Short-descriptor translation scheme.

boolean AArch32.DomainValid(Fault statuscode, integer level)
    assert statuscode != Fault_None;

    case statuscode of
        when Fault_Domain
            return TRUE;
        when Fault_Translation, Fault_AccessFlag, Fault_SyncExternalOnWalk, Fault_SyncParityOnWalk
            return level == 2;
        otherwise
            return FALSE;
```

## Library pseudocode for aarch32/functions/aborts/AArch32.FaultStatusLD

```
// AArch32.FaultStatusLD()
// =====
// Creates an exception fault status value for Abort and Watchpoint exceptions taken
// to Abort mode using AArch32 and Long-descriptor format.

bits(32) AArch32.FaultStatusLD(boolean d_side, FaultRecord fault)
    assert fault.statuscode != Fault_None;

    bits(32) fsr = Zeros();
    if HaveRASExt() && IsAsyncAbort(fault) then fsr<15:14> = fault.errortype;
    if d_side then
        if fault.acctype IN {AccType_DC, AccType_IC,
                             AccType_AT, AccType_ATPAN} then
            fsr<13> = '1'; fsr<11> = '1';
        else
            fsr<11> = if fault.write then '1' else '0';
    if IsExternalAbort(fault) then fsr<12> = fault.extflag;
    fsr<9> = '1';
    fsr<5:0> = EncodeLDFSC(fault.statuscode, fault.level);

    return fsr;
```



## Library pseudocode for aarch32/functions/aborts/AArch32.FaultStatusSD

```
// AArch32.FaultStatusSD()
// =====
// Creates an exception fault status value for Abort and Watchpoint exceptions taken
// to Abort mode using AArch32 and Short-descriptor format.

bits(32) AArch32.FaultStatusSD(boolean d_side, FaultRecord fault)
    assert fault.statuscode != Fault\_None;

    bits(32) fsr = Zeros\(\);
    if HaveRASExt\(\) && IsAsyncAbort(fault) then fsr<15:14> = fault.errortype;
    if d_side then
        if fault.acctype IN {AccType\_DC, AccType\_IC,
            AccType\_AT, AccType\_ATPAN} then
            fsr<13> = '1'; fsr<11> = '1';
        else
            fsr<11> = if fault.write then '1' else '0';
    if IsExternalAbort(fault) then fsr<12> = fault.extflag;
    fsr<9> = '0';
    fsr<10,3:0> = EncodeSDFSC(fault.statuscode, fault.level);
    if d_side then
        fsr<7:4> = fault.domain; // Domain field (data fault only)

    return fsr;
```

## Library pseudocode for aarch32/functions/aborts/AArch32.FaultSyndrome

```
// AArch32.FaultSyndrome()
// =====
// Creates an exception syndrome value for Abort and Watchpoint exceptions taken to
// AArch32 Hyp mode.

bits(25) AArch32.FaultSyndrome(boolean d_side, FaultRecord fault)
    assert fault.statuscode != Fault\_None;

    bits(25) iss = Zeros\(\);

    if HaveRASExt\(\) && IsAsyncAbort(fault) then
        iss<11:10> = fault.errortype; // AET

    if d_side then
        if (IsSecondStage(fault) && !fault.s2fslwalk &&
            (!IsExternalSyncAbort(fault) ||
            (!HaveRASExt\(\) && fault.acctype == AccType\_TTW &&
            boolean IMPLEMENTATION_DEFINED "ISV on second stage translation table walk")))) then
            iss<24:14> = LSInstructionSyndrome();

        if fault.acctype IN {AccType\_DC, AccType\_IC, AccType\_AT, AccType\_ATPAN} then
            iss<8> = '1'; iss<6> = '1';
        else
            iss<6> = if fault.write then '1' else '0';

    if IsExternalAbort(fault) then iss<9> = fault.extflag;
    iss<7> = if fault.s2fslwalk then '1' else '0';
    iss<5:0> = EncodeLDFSC(fault.statuscode, fault.level);

    return iss;
```

## Library pseudocode for aarch32/functions/aborts/EncodeSDFSC

```
// EncodeSDFSC()
// =====
// Function that gives the Short-descriptor FSR code for different types of Fault
bits(5) EncodeSDFSC(Fault statuscode, integer level)

bits(5) result;
case statuscode of
  when Fault\_AccessFlag
    assert level IN {1,2};
    result = if level == 1 then '00011' else '00110';
  when Fault\_Alignment
    result = '00001';
  when Fault\_Permission
    assert level IN {1,2};
    result = if level == 1 then '01101' else '01111';
  when Fault\_Domain
    assert level IN {1,2};
    result = if level == 1 then '01001' else '01011';
  when Fault\_Translation
    assert level IN {1,2};
    result = if level == 1 then '00101' else '00111';
  when Fault\_SyncExternal
    result = '01000';
  when Fault\_SyncExternalOnWalk
    assert level IN {1,2};
    result = if level == 1 then '01100' else '01110';
  when Fault\_SyncParity
    result = '11001';
  when Fault\_SyncParityOnWalk
    assert level IN {1,2};
    result = if level == 1 then '11100' else '11110';
  when Fault\_AsyncParity
    result = '11000';
  when Fault\_AsyncExternal
    result = '10110';
  when Fault\_Debug
    result = '00010';
  when Fault\_TLBConflict
    result = '10000';
  when Fault\_Lockdown
    result = '10100'; // IMPLEMENTATION DEFINED
  when Fault\_Exclusive
    result = '10101'; // IMPLEMENTATION DEFINED
  when Fault\_ICacheMaint
    result = '00100';
  otherwise
    Unreachable\(\);

return result;
```

## Library pseudocode for aarch32/functions/common/A32ExpandImm

```
// A32ExpandImm()
// =====

bits(32) A32ExpandImm(bits(12) imm12)

// PSTATE.C argument to following function call does not affect the imm32 result.
(imm32, -) = A32ExpandImm\_C(imm12, PSTATE.C);

return imm32;
```

## Library pseudocode for aarch32/functions/common/A32ExpandImm\_C

```
// A32ExpandImm_C()
// =====

(bits(32), bit) A32ExpandImm_C(bits(12) imm12, bit carry_in)

    unrotated_value = ZeroExtend(imm12<7:0>, 32);
    (imm32, carry_out) = Shift_C(unrotated_value, SRTYPE_ROR, 2*UInt(imm12<11:8>), carry_in);

    return (imm32, carry_out);
```

## Library pseudocode for aarch32/functions/common/DecodeImmShift

```
// DecodeImmShift()
// =====

(SRType, integer) DecodeImmShift(bits(2) srtype, bits(5) imm5)

    case srtype of
        when '00'
            shift_t = SRTYPE_LSL; shift_n = UInt(imm5);
        when '01'
            shift_t = SRTYPE_LSR; shift_n = if imm5 == '00000' then 32 else UInt(imm5);
        when '10'
            shift_t = SRTYPE_ASR; shift_n = if imm5 == '00000' then 32 else UInt(imm5);
        when '11'
            if imm5 == '00000' then
                shift_t = SRTYPE_RRX; shift_n = 1;
            else
                shift_t = SRTYPE_ROR; shift_n = UInt(imm5);

    return (shift_t, shift_n);
```

## Library pseudocode for aarch32/functions/common/DecodeRegShift

```
// DecodeRegShift()
// =====

SRType DecodeRegShift(bits(2) srtype)
    case srtype of
        when '00' shift_t = SRTYPE_LSL;
        when '01' shift_t = SRTYPE_LSR;
        when '10' shift_t = SRTYPE_ASR;
        when '11' shift_t = SRTYPE_ROR;
    return shift_t;
```

## Library pseudocode for aarch32/functions/common/RRX

```
// RRX()
// =====

bits(N) RRX(bits(N) x, bit carry_in)
    (result, -) = RRX_C(x, carry_in);
    return result;
```

## Library pseudocode for aarch32/functions/common/RRX\_C

```
// RRX_C()
// =====

(bits(N), bit) RRX_C(bits(N) x, bit carry_in)
    result = carry_in : x<N-1:1>;
    carry_out = x<0>;
    return (result, carry_out);
```

## Library pseudocode for aarch32/functions/common/SRType

```
enumeration SRType {SRType_LSL, SRType_LSR, SRType_ASR, SRType_ROR, SRType_RRX};
```

## Library pseudocode for aarch32/functions/common/Shift

```
// Shift()
// =====

bits(N) Shift(bits(N) value, SRType srtype, integer amount, bit carry_in)
    (result, -) = Shift\_C(value, srtype, amount, carry_in);
    return result;
```

## Library pseudocode for aarch32/functions/common/Shift\_C

```
// Shift_C()
// =====

(bits(N), bit) Shift_C(bits(N) value, SRType srtype, integer amount, bit carry_in)
    assert !(srtype == SRType\_RRX && amount != 1);

    if amount == 0 then
        (result, carry_out) = (value, carry_in);
    else
        case srtype of
            when SRType\_LSL
                (result, carry_out) = LSL\_C(value, amount);
            when SRType\_LSR
                (result, carry_out) = LSR\_C(value, amount);
            when SRType\_ASR
                (result, carry_out) = ASR\_C(value, amount);
            when SRType\_ROR
                (result, carry_out) = ROR\_C(value, amount);
            when SRType\_RRX
                (result, carry_out) = RRX\_C(value, carry_in);

    return (result, carry_out);
```

## Library pseudocode for aarch32/functions/common/T32ExpandImm

```
// T32ExpandImm()
// =====

bits(32) T32ExpandImm(bits(12) imm12)

    // PSTATE.C argument to following function call does not affect the imm32 result.
    (imm32, -) = T32ExpandImm\_C(imm12, PSTATE.C);

    return imm32;
```

## Library pseudocode for aarch32/functions/common/T32ExpandImm\_C

```
// T32ExpandImm_C()
// =====

(bits(32), bit) T32ExpandImm_C(bits(12) imm12, bit carry_in)

    if imm12<11:10> == '00' then
        case imm12<9:8> of
            when '00'
                imm32 = ZeroExtend(imm12<7:0>, 32);
            when '01'
                imm32 = '00000000' : imm12<7:0> : '00000000' : imm12<7:0>;
            when '10'
                imm32 = imm12<7:0> : '00000000' : imm12<7:0> : '00000000';
            when '11'
                imm32 = imm12<7:0> : imm12<7:0> : imm12<7:0> : imm12<7:0>;
        carry_out = carry_in;
    else
        unrotated_value = ZeroExtend('1':imm12<6:0>, 32);
        (imm32, carry_out) = ROR_C(unrotated_value, UInt(imm12<11:7>));

    return (imm32, carry_out);
```

## Library pseudocode for aarch32/functions/common/VCGEType

```
enumeration VCGEType {VCGEType_signed, VCGEType_unsigned, VCGEType_fp};
```

## Library pseudocode for aarch32/functions/common/VFPNegMul

```
enumeration VFPNegMul {VFPNegMul_VNMLA, VFPNegMul_VNMLS, VFPNegMul_VNMUL};
```

## Library pseudocode for aarch32/functions/coproc/AArch32.CheckCP15InstrCoarseTraps

```
// AArch32.CheckCP15InstrCoarseTraps()
// =====
// Check for coarse-grained CP15 traps in HSTR and HCR.

boolean AArch32.CheckCP15InstrCoarseTraps(integer CRn, integer nreg, integer CRm)

    // Check for coarse-grained Hyp traps
    if PSTATE.EL IN {EL0, EL1} && EL2Enabled() then
        if PSTATE.EL == EL0 && !ELUsingAArch32(EL2) then
            return AArch64.CheckCP15InstrCoarseTraps(CRn, nreg, CRm);
        // Check for MCR, MRC, MCRR and MRRC disabled by HSTR<CRn/CRm>
        major = if nreg == 1 then CRn else CRm;
        if !(major IN {4,14}) && HSTR<major> == '1' then
            return TRUE;

        // Check for MRC and MCR disabled by HCR.TIDCP
        if (HCR.TIDCP == '1' && nreg == 1 &&
            ((CRn == 9 && CRm IN {0,1,2, 5,6,7,8 }) ||
             (CRn == 10 && CRm IN {0,1, 4, 8 }) ||
             (CRn == 11 && CRm IN {0,1,2,3,4,5,6,7,8,15}))) then
            return TRUE;

    return FALSE;
```

## Library pseudocode for aarch32/functions/exclusive/AArch32.ExclusiveMonitorsPass

```
// AArch32.ExclusiveMonitorsPass()
// =====
// Return TRUE if the Exclusives monitors for the current PE include all of the addresses
// associated with the virtual address region of size bytes starting at address.
// The immediately following memory write must be to the same addresses.

boolean AArch32.ExclusiveMonitorsPass(bits(32) address, integer size)

    // It is IMPLEMENTATION DEFINED whether the detection of memory aborts happens
    // before or after the check on the local Exclusives monitor. As a result a failure
    // of the local monitor can occur on some implementations even if the memory
    // access would give an memory abort.

    acctype = AccType_ATOMIC;
    iswrite = TRUE;

    aligned = AArch32.CheckAlignment(address, size, acctype, iswrite);

    passed = AArch32.IsExclusiveVA(address, ProcessorID(), size);
    if !passed then
        return FALSE;

    memaddrdesc = AArch32.TranslateAddress(address, acctype, iswrite, aligned, size);
    // Check for aborts or debug exceptions
    if IsFault(memaddrdesc) then
        AArch32.Abort(address, memaddrdesc.fault);

    passed = IsExclusiveLocal(memaddrdesc.paddress, ProcessorID(), size);
    ClearExclusiveLocal(ProcessorID());

    if passed then
        if memaddrdesc.memattrs.shareability != Shareability_NSH then
            passed = IsExclusiveGlobal(memaddrdesc.paddress, ProcessorID(), size);

    return passed;
```

## Library pseudocode for aarch32/functions/exclusive/AArch32.IsExclusiveVA

```
// An optional IMPLEMENTATION DEFINED test for an exclusive access to a virtual
// address region of size bytes starting at address.
//
// It is permitted (but not required) for this function to return FALSE and
// cause a store exclusive to fail if the virtual address region is not
// totally included within the region recorded by MarkExclusiveVA().
//
// It is always safe to return TRUE which will check the physical address only.
boolean AArch32.IsExclusiveVA(bits(32) address, integer processorid, integer size);
```

## Library pseudocode for aarch32/functions/exclusive/AArch32.MarkExclusiveVA

```
// Optionally record an exclusive access to the virtual address region of size bytes
// starting at address for processorid.
AArch32.MarkExclusiveVA(bits(32) address, integer processorid, integer size);
```

## Library pseudocode for aarch32/functions/exclusive/AArch32.SetExclusiveMonitors

```
// AArch32.SetExclusiveMonitors()
// =====
// Sets the Exclusives monitors for the current PE to record the addresses associated
// with the virtual address region of size bytes starting at address.

AArch32.SetExclusiveMonitors(bits(32) address, integer size)
    acctype = AccType\_ATOMIC;
    iswrite = FALSE;

    aligned = AArch32.CheckAlignment(address, size, acctype, iswrite);

    memaddrdesc = AArch32.TranslateAddress(address, acctype, iswrite, aligned, size);
    // Check for aborts or debug exceptions
    if IsFault(memaddrdesc) then
        return;

    if memaddrdesc.memattrs.shareability != Shareability\_NSH then
        MarkExclusiveGlobal(memaddrdesc.paddress, ProcessorID\(\), size);

    MarkExclusiveLocal(memaddrdesc.paddress, ProcessorID\(\), size);

    AArch32.MarkExclusiveVA(address, ProcessorID\(\), size);
```

## Library pseudocode for aarch32/functions/float/CheckAdvSIMDEnabled

```
// CheckAdvSIMDEnabled()
// =====

CheckAdvSIMDEnabled()

    fpexc_check = TRUE;
    advsimd = TRUE;

    AArch32.CheckAdvSIMDOrFPEEnabled(fpexc_check, advsimd);
    // Return from CheckAdvSIMDOrFPEEnabled() occurs only if Advanced SIMD access is permitted

    // Make temporary copy of D registers
    // _Dclone[] is used as input data for instruction pseudocode
    for i = 0 to 31
        _Dclone[i] = D[i];

    return;
```

## Library pseudocode for aarch32/functions/float/CheckAdvSIMDOrVFPEEnabled

```
// CheckAdvSIMDOrVFPEEnabled()
// =====

CheckAdvSIMDOrVFPEEnabled(boolean include_fpexc_check, boolean advsimd)
    AArch32.CheckAdvSIMDOrFPEEnabled(include_fpexc_check, advsimd);
    // Return from CheckAdvSIMDOrFPEEnabled() occurs only if VFP access is permitted
    return;
```

## Library pseudocode for aarch32/functions/float/CheckCryptoEnabled32

```
// CheckCryptoEnabled32()
// =====

CheckCryptoEnabled32()
    CheckAdvSIMDEnabled();
    // Return from CheckAdvSIMDEnabled() occurs only if access is permitted
    return;
```

## Library pseudocode for aarch32/functions/float/CheckVFPEEnabled

```
// CheckVFPEEnabled()
// =====

CheckVFPEEnabled(boolean include_fpexc_check)
    advsimd = FALSE;
    AArch32.CheckAdvSIMDOrFPEEnabled(include_fpexc_check, advsimd);
    // Return from CheckAdvSIMDOrFPEEnabled() occurs only if VFP access is permitted
    return;
```

## Library pseudocode for aarch32/functions/float/FPHalvedSub

```
// FPHalvedSub()
// =====

bits(N) FPHalvedSub(bits(N) op1, bits(N) op2, FPCRTType fpcr)
    assert N IN {16,32,64};
    rounding = FPRoundingMode(fpcr);
    (type1,sign1,value1) = FPUnpack(op1, fpcr);
    (type2,sign2,value2) = FPUnpack(op2, fpcr);
    (done,result) = FPProcessNaNs(type1, type2, op1, op2, fpcr);
    if !done then
        inf1 = (type1 == FPTYPE\_Infinity); inf2 = (type2 == FPTYPE\_Infinity);
        zero1 = (type1 == FPTYPE\_Zero); zero2 = (type2 == FPTYPE\_Zero);
        if inf1 && inf2 && sign1 == sign2 then
            result = FPDefaultNaN(fpcr);
            FPProcessException(FPExc\_InvalidOp, fpcr);
        elsif (inf1 && sign1 == '0') || (inf2 && sign2 == '1') then
            result = FPInfinity('0');
        elsif (inf1 && sign1 == '1') || (inf2 && sign2 == '0') then
            result = FPInfinity('1');
        elsif zero1 && zero2 && sign1 != sign2 then
            result = FPZero(sign1);
        else
            result_value = (value1 - value2) / 2.0;
            if result_value == 0.0 then // Sign of exact zero result depends on rounding mode
                result_sign = if rounding == FPRounding\_NEGINF then '1' else '0';
                result = FPZero(result_sign);
            else
                result = FPRound(result_value, fpcr);
    return result;
```

## Library pseudocode for aarch32/functions/float/FPRSqrtStep

```
// FPRSqrtStep()
// =====

bits(N) FPRSqrtStep(bits(N) op1, bits(N) op2)
    assert N IN {16,32};
    FPCRTType fpcr = StandardFPSCRValue();
    (type1,sign1,value1) = FPUnpack(op1, fpcr);
    (type2,sign2,value2) = FPUnpack(op2, fpcr);
    (done,result) = FPProcessNaNs(type1, type2, op1, op2, fpcr);
    if !done then
        inf1 = (type1 == FPTYPE\_Infinity); inf2 = (type2 == FPTYPE\_Infinity);
        zero1 = (type1 == FPTYPE\_Zero); zero2 = (type2 == FPTYPE\_Zero);
        bits(N) product;
        if (inf1 && zero2) || (zero1 && inf2) then
            product = FPZero('0');
        else
            product = FPMul(op1, op2, fpcr);
        bits(N) three = FPThree('0');
        result = FPHalvedSub(three, product, fpcr);
    return result;
```



## Library pseudocode for aarch32/functions/float/FPRecipStep

```
// FPRecipStep()
// =====

bits(N) FPRecipStep(bits(N) op1, bits(N) op2)
    assert N IN {16,32};
    FPCRTType fpcr = StandardFPSCRValue();
    (type1,sign1,value1) = FPUnpack(op1, fpcr);
    (type2,sign2,value2) = FPUnpack(op2, fpcr);
    (done,result) = FPProcessNaNs(type1, type2, op1, op2, fpcr);
    if !done then
        inf1 = (type1 == FPCRTType_Infinity);  inf2 = (type2 == FPCRTType_Infinity);
        zero1 = (type1 == FPCRTType_Zero);      zero2 = (type2 == FPCRTType_Zero);
        bits(N) product;
        if (inf1 && zero2) || (zero1 && inf2) then
            product = FPZero('0');
        else
            product = FPMul(op1, op2, fpcr);
        bits(N) two = FPTwo('0');
        result = FPSub(two, product, fpcr);
    return result;
```

## Library pseudocode for aarch32/functions/float/StandardFPSCRValue

```
// StandardFPSCRValue()
// =====

FPCRTType StandardFPSCRValue()
    bits(32) upper = '00000000000000000000000000000000';
    bits(32) lower = '00000' : FPSCR.AHP : '110000' : FPSCR.FZ16 : '0000000000000000000000';
    return upper : lower;
```

## Library pseudocode for aarch32/functions/memory/AArch32.CheckAlignment

```
// AArch32.CheckAlignment()
// =====

boolean AArch32.CheckAlignment(bits(32) address, integer alignment, AccType acctype,
                                boolean iswrite)

    if PSTATE.EL == EL0 && !ELUsingAArch32(S1TranslationRegime()) then
        A = SCTLRL.A; //use AArch64 register, when higher Exception level is using AArch64
    elsif PSTATE.EL == EL2 then
        A = HSCTLRL.A;
    else
        A = SCTLRL.A;
    aligned = (address == Align(address, alignment));
    atomic = acctype IN { AccType_ATOMIC, AccType_ATOMICRW, AccType_ORDEREDATOMIC,
                          AccType_ORDEREDATOMICRW, AccType_ATOMICLS64, AccType_A32LSMD };
    ordered = acctype IN { AccType_ORDERED, AccType_ORDEREDRW, AccType_LIMITEDORDERED, AccType_ORDEREDATOMIC };
    vector = acctype == AccType_VEC;

    // AccType_VEC is used for SIMD element alignment checks only
    check = (atomic || ordered || vector || A == '1');

    if check && !aligned then
        secondstage = FALSE;
        AArch32.Abort(address, AlignmentFault(acctype, iswrite, secondstage));

    return aligned;
```

## Library pseudocode for aarch32/functions/memory/AArch32.MemSingle

```
// AArch32.MemSingle[] - non-assignment (read) form
// =====
// Perform an atomic, little-endian read of 'size' bytes.

bits(size*8) AArch32.MemSingle[bits(32) address, integer size, AccType acctype, boolean wasaligned]
    boolean ispair = FALSE;
    return AArch32.MemSingle[address, size, acctype, wasaligned, ispair];

// AArch32.MemSingle[] - non-assignment (read) form
// =====
// Perform an atomic, little-endian read of 'size' bytes.

bits(size*8) AArch32.MemSingle[bits(32) address, integer size, AccType acctype, boolean wasaligned, boolean ispair]
    assert size IN {1, 2, 4, 8, 16};
    assert address == Align(address, size);

    AddressDescriptor memaddrdesc;
    bits(size*8) value;
    iswrite = FALSE;

    memaddrdesc = AArch32.TranslateAddress(address, acctype, iswrite, wasaligned, size);
    // Check for aborts or debug exceptions
    if IsFault(memaddrdesc) then
        AArch32.Abort(address, memaddrdesc.fault);

    // Memory array access
    accdesc = CreateAccessDescriptor(acctype);

    value = _Mem[memaddrdesc, size, accdesc, FALSE];

    return value;

// AArch32.MemSingle[] - assignment (write) form
// =====

AArch32.MemSingle[bits(32) address, integer size, AccType acctype, boolean wasaligned] = bits(size*8) value
    boolean ispair = FALSE;
    AArch32.MemSingle[address, size, acctype, wasaligned, ispair] = value;
    return;

// AArch32.MemSingle[] - assignment (write) form
// =====
// Perform an atomic, little-endian write of 'size' bytes.

AArch32.MemSingle[bits(32) address, integer size, AccType acctype, boolean wasaligned, boolean ispair] = bits(size*8) value
    assert size IN {1, 2, 4, 8, 16};
    assert address == Align(address, size);

    AddressDescriptor memaddrdesc;
    iswrite = TRUE;

    memaddrdesc = AArch32.TranslateAddress(address, acctype, iswrite, wasaligned, size);
    // Check for aborts or debug exceptions
    if IsFault(memaddrdesc) then
        AArch32.Abort(address, memaddrdesc.fault);

    // Effect on exclusives
    if memaddrdesc.memattrs.shareability != Shareability\_NSH then
        ClearExclusiveByAddress(memaddrdesc.paddress, ProcessorID(), size);

    // Memory array access
    accdesc = CreateAccessDescriptor(acctype);

    _Mem[memaddrdesc, size, accdesc] = value;
    return;
```

### Library pseudocode for aarch32/functions/memory/Hint\_PreloadData

```
Hint_PreloadData(bits(32) address);
```

### Library pseudocode for aarch32/functions/memory/Hint\_PreloadDataForWrite

```
Hint_PreloadDataForWrite(bits(32) address);
```

### Library pseudocode for aarch32/functions/memory/Hint\_PreloadInstr

```
Hint_PreloadInstr(bits(32) address);
```

### Library pseudocode for aarch32/functions/memory/MemA

```
// MemA[] - non-assignment form
// =====

bits(8*size) MemA(bits(32) address, integer size)
    acctype = AccType\_ATOMIC;
    return Mem\_with\_type[address, size, acctype];

// MemA[] - assignment form
// =====

MemA(bits(32) address, integer size) = bits(8*size) value
    acctype = AccType\_ATOMIC;
    Mem\_with\_type[address, size, acctype] = value;
    return;
```

### Library pseudocode for aarch32/functions/memory/MemO

```
// MemO[] - non-assignment form
// =====

bits(8*size) MemO(bits(32) address, integer size)
    acctype = AccType\_ORDERED;
    return Mem\_with\_type[address, size, acctype];

// MemO[] - assignment form
// =====

MemO(bits(32) address, integer size) = bits(8*size) value
    acctype = AccType\_ORDERED;
    Mem\_with\_type[address, size, acctype] = value;
    return;
```

### Library pseudocode for aarch32/functions/memory/MemS

```
// MemS[] - non-assignment form
// =====
// Memory accessor for streaming load multiple instructions

bits(8*size) MemS(bits(32) address, integer size)
    acctype = AccType\_A32LSMD;
    return Mem\_with\_type[address, size, acctype];

// MemS[] - assignment form
// =====
// Memory accessor for streaming store multiple instructions

MemS(bits(32) address, integer size) = bits(8*size) value
    acctype = AccType\_A32LSMD;
    Mem\_with\_type[address, size, acctype] = value;
    return;
```

## Library pseudocode for aarch32/functions/memory/MemU

```
// MemU[] - non-assignment form
// =====

bits(8*size) MemU[bits(32) address, integer size]
    acctype = AccType\_NORMAL;
    return Mem\_with\_type[address, size, acctype];

// MemU[] - assignment form
// =====

MemU[bits(32) address, integer size] = bits(8*size) value
    acctype = AccType\_NORMAL;
    Mem\_with\_type[address, size, acctype] = value;
    return;
```

## Library pseudocode for aarch32/functions/memory/MemU\_unpriv

```
// MemU_unpriv[] - non-assignment form
// =====

bits(8*size) MemU_unpriv[bits(32) address, integer size]
    acctype = AccType\_UNPRIV;
    return Mem\_with\_type[address, size, acctype];

// MemU_unpriv[] - assignment form
// =====

MemU_unpriv[bits(32) address, integer size] = bits(8*size) value
    acctype = AccType\_UNPRIV;
    Mem\_with\_type[address, size, acctype] = value;
    return;
```



```

// Mem_with_type[] - non-assignment (read) form
// =====
// Perform a read of 'size' bytes. The access byte order is reversed for a big-endian access.
// Instruction fetches would call AArch32.MemSingle directly.

bits(size*8) Mem_with_type[bits(32) address, integer size, AccType acctype]
    boolean ispair = FALSE;
    return Mem_with_type[address, size, acctype, ispair];

bits(size*8) Mem_with_type[bits(32) address, integer size, AccType acctype, boolean ispair]
    assert size IN {1, 2, 4, 8, 16};
    bits(size*8) value;
    boolean iswrite = FALSE;
    integer halfsize = size DIV 2;

    if ispair then
        // check alignment on size of element accessed, not overall access size
        aligned = AArch32.CheckAlignment(address, halfsize, acctype, iswrite);
    else
        aligned = AArch32.CheckAlignment(address, size, acctype, iswrite);

    if !aligned then

        assert size > 1;
        value<7:0> = AArch32.MemSingle[address, 1, acctype, aligned];

        // For subsequent bytes it is CONSTRAINED UNPREDICTABLE whether an unaligned Device memory
        // access will generate an Alignment Fault, as to get this far means the first byte did
        // not, so we must be changing to a new translation page.
        c = ConstrainUnpredictable(Unpredictable_DEVPAGE2);
        assert c IN {Constraint_FAULT, Constraint_NONE};
        if c == Constraint_NONE then aligned = TRUE;

        for i = 1 to size-1
            value<8*i+7:8*i> = AArch32.MemSingle[address+i, 1, acctype, aligned];
    else
        value = AArch32.MemSingle[address, size, acctype, aligned, ispair];

    if BigEndian(acctype) then
        value = BigEndianReverse(value);

    return value;

// Mem_with_type[] - assignment (write) form
// =====
// Perform a write of 'size' bytes. The byte order is reversed for a big-endian access.

Mem_with_type[bits(32) address, integer size, AccType acctype] = bits(size*8) value
    boolean ispair = FALSE;
    Mem_with_type[address, size, acctype, ispair] = value;

Mem_with_type[bits(32) address, integer size, AccType acctype, boolean ispair] = bits(size*8) value
    boolean iswrite = TRUE;
    integer halfsize = size DIV 2;

    if BigEndian(acctype) then
        value = BigEndianReverse(value);

    if ispair then
        // check alignment on size of element accessed, not overall access size
        aligned = AArch32.CheckAlignment(address, halfsize, acctype, iswrite);
    else
        aligned = AArch32.CheckAlignment(address, size, acctype, iswrite);

    if !aligned then
        assert size > 1;
        AArch32.MemSingle[address, 1, acctype, aligned] = value<7:0>;

        // For subsequent bytes it is CONSTRAINED UNPREDICTABLE whether an unaligned Device memory
        // access will generate an Alignment Fault, as to get this far means the first byte did

```

```

// not, so we must be changing to a new translation page.
c = ConstrainUnpredictable\(Unpredictable\_DEVPAGE2\);
assert c IN {Constraint\_FAULT, Constraint\_NONE};
if c == Constraint\_NONE then aligned = TRUE;

for i = 1 to size-1
    AArch32.MemSingle[address+i, 1, acctype, aligned] = value<8*i+7:8*i>;
else
    AArch32.MemSingle[address, size, acctype, aligned, ispair] = value;
return;

```

### Library pseudocode for aarch32/functions/ras/AArch32.ESBOperation

```

// AArch32.ESBOperation()
// =====
// Perform the AArch32 ESB operation for ESB executed in AArch32 state

AArch32.ESBOperation()

// Check if routed to AArch64 state
route_to_aarch64 = PSTATE.EL == EL0 && !ELUsingAArch32\(EL1\);
if !route_to_aarch64 && EL2Enabled\(\) && !ELUsingAArch32\(EL2\) then
    route_to_aarch64 = HCR_EL2.TGE == '1' || HCR_EL2.AMO == '1';
if !route_to_aarch64 && HaveEL\(EL3\) && !ELUsingAArch32\(EL3\) then
    route_to_aarch64 = SCR_EL3.EA == '1';

if route_to_aarch64 then
    AArch64.ESBOperation\(\);
    return;

route_to_monitor = HaveEL\(EL3\) && ELUsingAArch32\(EL3\) && SCR.EA == '1';
route_to_hyp = PSTATE.EL IN {EL0, EL1} && EL2Enabled\(\) && (HCR.TGE == '1' || HCR.AMO == '1');

if route_to_monitor then
    target = M32\_Monitor;
elseif route_to_hyp || PSTATE.M == M32\_Hyp then
    target = M32\_Hyp;
else
    target = M32\_Abort;

if IsSecure\(\) then
    mask_active = TRUE;
elseif target == M32\_Monitor then
    mask_active = SCR.AW == '1' && (!HaveEL\(EL2\) || (HCR.TGE == '0' && HCR.AMO == '0'));
else
    mask_active = target == M32\_Abort || PSTATE.M == M32\_Hyp;

mask_set = PSTATE.A == '1';
(-, el) = ELFromM32\(target\);
intdis = Halted\(\) || ExternalDebugInterruptsDisabled\(el\);
masked = intdis || (mask_active && mask_set);

// Check for a masked Physical SError pending that can be synchronized
// by an Error synchronization event.
if masked && IsSynchronizablePhysicalSErrorPending\(\) then
    syndrome32 = AArch32.PhysicalSErrorSyndrome\(\);
    DISR = AArch32.ReportDeferredSError(syndrome32.AET, syndrome32.ExT);
    ClearPendingPhysicalSError\(\);

return;

```

### Library pseudocode for aarch32/functions/ras/AArch32.PhysicalSErrorSyndrome

```

// Return the SError syndrome
AArch32.SErrorSyndrome AArch32.PhysicalSErrorSyndrome();

```

## Library pseudocode for aarch32/functions/ras/AArch32.ReportDeferredSError

```
// AArch32.ReportDeferredSError()
// =====
// Return deferred SError syndrome

bits(32) AArch32.ReportDeferredSError(bits(2) AET, bit ExT)
    bits(32) target;
    target<31> = '1'; // A
    syndrome = Zeros(16);
    if PSTATE.EL == EL2 then
        syndrome<11:10> = AET; // AET
        syndrome<9> = ExT; // EA
        syndrome<5:0> = '010001'; // DFSC
    else
        syndrome<15:14> = AET; // AET
        syndrome<12> = ExT; // ExT
        syndrome<9> = TTBCR.EAE; // LPAE
        if TTBCR.EAE == '1' then // Long-descriptor format
            syndrome<5:0> = '010001'; // STATUS
        else // Short-descriptor format
            syndrome<10,3:0> = '10110'; // FS
    if HaveAnyAArch64() then
        target<24:0> = ZeroExtend(syndrome); // Any RES0 fields must be set to zero
    else
        target<15:0> = syndrome;
    return target;
```

## Library pseudocode for aarch32/functions/ras/AArch32.SErrorSyndrome

```
type AArch32.SErrorSyndrome is (
    bits(2) AET,
    bit ExT
)
```

## Library pseudocode for aarch32/functions/ras/AArch32.vESB0Operation

```
// AArch32.vESB0Operation()
// =====
// Perform the ESB operation for virtual SError interrupts executed in AArch32 state

AArch32.vESB0Operation()
    assert PSTATE.EL IN {EL0, EL1} && EL2Enabled();

    // Check for EL2 using AArch64 state
    if !ELUsingAArch32(EL2) then
        AArch64.vESB0Operation();
        return;

    // If physical SError interrupts are routed to Hyp mode, and TGE is not set, then a
    // virtual SError interrupt might be pending
    vSEI_enabled = HCR.TGE == '0' && HCR.AMO == '1';
    vSEI_pending = vSEI_enabled && HCR.VA == '1';
    vintdis = Halted() || ExternalDebugInterruptsDisabled(EL1);
    vmasked = vintdis || PSTATE.A == '1';

    // Check for a masked virtual SError pending
    if vSEI_pending && vmasked then
        VDISR = AArch32.ReportDeferredSError(VDFSR<15:14>, VDFSR<12>);
        HCR.VA = '0'; // Clear pending virtual SError

    return;
```



## Library pseudocode for aarch32/functions/registers/AArch32.ResetGeneralRegisters

```
// AArch32.ResetGeneralRegisters()
// =====

AArch32.ResetGeneralRegisters()

    for i = 0 to 7
        R[i] = bits(32) UNKNOWN;
    for i = 8 to 12
        Rmode[i, M32_User] = bits(32) UNKNOWN;
        Rmode[i, M32_FIQ] = bits(32) UNKNOWN;
    if HaveEL(EL2) then Rmode[13, M32_Hyp] = bits(32) UNKNOWN;    // No R14_hyp
    for i = 13 to 14
        Rmode[i, M32_User] = bits(32) UNKNOWN;
        Rmode[i, M32_FIQ] = bits(32) UNKNOWN;
        Rmode[i, M32_IRQ] = bits(32) UNKNOWN;
        Rmode[i, M32_Svc] = bits(32) UNKNOWN;
        Rmode[i, M32_Abort] = bits(32) UNKNOWN;
        Rmode[i, M32_Undef] = bits(32) UNKNOWN;
        if HaveEL(EL3) then Rmode[i, M32_Monitor] = bits(32) UNKNOWN;

    return;
```

## Library pseudocode for aarch32/functions/registers/AArch32.ResetSIMDFPRegisters

```
// AArch32.ResetSIMDFPRegisters()
// =====

AArch32.ResetSIMDFPRegisters()

    for i = 0 to 15
        Q[i] = bits(128) UNKNOWN;

    return;
```

## Library pseudocode for aarch32/functions/registers/AArch32.ResetSpecialRegisters

```
// AArch32.ResetSpecialRegisters()
// =====

AArch32.ResetSpecialRegisters()

    // AArch32 special registers
    SPSR_fiq<31:0> = bits(32) UNKNOWN;
    SPSR_irq<31:0> = bits(32) UNKNOWN;
    SPSR_svc<31:0> = bits(32) UNKNOWN;
    SPSR_abt<31:0> = bits(32) UNKNOWN;
    SPSR_und<31:0> = bits(32) UNKNOWN;
    if HaveEL(EL2) then
        SPSR_hyp = bits(32) UNKNOWN;
        ELR_hyp = bits(32) UNKNOWN;
    if HaveEL(EL3) then
        SPSR_mon = bits(32) UNKNOWN;

    // External debug special registers
    DLR = bits(32) UNKNOWN;
    DSPSR = bits(32) UNKNOWN;

    return;
```

## Library pseudocode for aarch32/functions/registers/AArch32.ResetSystemRegisters

```
AArch32.ResetSystemRegisters(boolean cold_reset);
```

## Library pseudocode for aarch32/functions/registers/ALUExceptionReturn

```
// ALUExceptionReturn()
// =====

ALUExceptionReturn(bits(32) address)
  if PSTATE.EL == EL2 then
    UNDEFINED;
  elsif PSTATE.M IN {M32\_User,M32\_System} then
    Constraint c = ConstrainUnpredictable(Unpredictable\_ALUEXCEPTIONRETURN);
    assert c IN {Constraint\_UNDEF, Constraint\_NOP};
    case c of
      when Constraint\_UNDEF
        UNDEFINED;
      when Constraint\_NOP
        EndOfInstruction();
    else
      AArch32.ExceptionReturn(address, SPSR[]);
```

## Library pseudocode for aarch32/functions/registers/ALUWritePC

```
// ALUWritePC()
// =====

ALUWritePC(bits(32) address)
  if CurrentInstrSet() == InstrSet\_A32 then
    BXWritePC(address, BranchType\_INDIR);
  else
    BranchWritePC(address, BranchType\_INDIR);
```

## Library pseudocode for aarch32/functions/registers/BXWritePC

```
// BXWritePC()
// =====

BXWritePC(bits(32) address, BranchType branch_type)
  if address<0> == '1' then
    SelectInstrSet(InstrSet\_T32);
    address<0> = '0';
  else
    SelectInstrSet(InstrSet\_A32);
    // For branches to an unaligned PC counter in A32 state, the processor takes the branch
    // and does one of:
    // * Forces the address to be aligned
    // * Leaves the PC unaligned, meaning the target generates a PC Alignment fault.
    if address<1> == '1' && ConstrainUnpredictableBool(Unpredictable\_A32FORCEALIGNPC) then
      address<1> = '0';
    boolean branch_conditional = AArch32.CurrentCond() != '111x';
    BranchTo(address, branch_type, branch_conditional);
```

## Library pseudocode for aarch32/functions/registers/BranchWritePC

```
// BranchWritePC()
// =====

BranchWritePC(bits(32) address, BranchType branch_type)
  if CurrentInstrSet() == InstrSet\_A32 then
    address<1:0> = '00';
  else
    address<0> = '0';
  boolean branch_conditional = AArch32.CurrentCond() != '111x';
  BranchTo(address, branch_type, branch_conditional);
```

## Library pseudocode for aarch32/functions/registers/CBWritePC

```
// CBWritePC()
// =====
// Takes a branch from a CBNZ/CBZ instruction.

CBWritePC(bits(32) address)
    assert CurrentInstrSet\(\) == InstrSet\_T32;
    address<0> = '0';
    boolean branch_conditional = TRUE;
    BranchTo(address, BranchType\_DIR, branch_conditional);
```

## Library pseudocode for aarch32/functions/registers/D

```
// D[] - non-assignment form
// =====

bits(64) D[integer n]
    assert n >= 0 && n <= 31;
    base = (n MOD 2) * 64;
    bits(128) vreg = V[n DIV 2];
    return vreg<base+63:base>;

// D[] - assignment form
// =====

D[integer n] = bits(64) value
    assert n >= 0 && n <= 31;
    base = (n MOD 2) * 64;
    bits(128) vreg = V[n DIV 2];
    vreg<base+63:base> = value;
    V[n DIV 2] = vreg;
    return;
```

## Library pseudocode for aarch32/functions/registers/Din

```
// Din[] - non-assignment form
// =====

bits(64) Din[integer n]
    assert n >= 0 && n <= 31;
    return \_Dclone[n];
```

## Library pseudocode for aarch32/functions/registers/LR

```
// LR - assignment form
// =====

LR = bits(32) value
    R[14] = value;
    return;

// LR - non-assignment form
// =====

bits(32) LR
    return R[14];
```

## Library pseudocode for aarch32/functions/registers/LoadWritePC

```
// LoadWritePC()
// =====

LoadWritePC(bits(32) address)
    BXWritePC(address, BranchType\_INDIR);
```

## Library pseudocode for aarch32/functions/registers/LookUpRIndex

```
// LookUpRIndex()
// =====

integer LookUpRIndex(integer n, bits(5) mode)
    assert n >= 0 && n <= 14;

    case n of // Select index by mode:      usr fiq irq svc abt und hyp
        when 8      result = RBankSelect(mode, 8, 24, 8, 8, 8, 8, 8);
        when 9      result = RBankSelect(mode, 9, 25, 9, 9, 9, 9, 9);
        when 10     result = RBankSelect(mode, 10, 26, 10, 10, 10, 10, 10);
        when 11     result = RBankSelect(mode, 11, 27, 11, 11, 11, 11, 11);
        when 12     result = RBankSelect(mode, 12, 28, 12, 12, 12, 12, 12);
        when 13     result = RBankSelect(mode, 13, 29, 17, 19, 21, 23, 15);
        when 14     result = RBankSelect(mode, 14, 30, 16, 18, 20, 22, 14);
        otherwise   result = n;

    return result;
```

## Library pseudocode for aarch32/functions/registers/Monitor\_mode\_registers

```
bits(32) SP_mon;
bits(32) LR_mon;
```

## Library pseudocode for aarch32/functions/registers/PC

```
// PC - non-assignment form
// =====

bits(32) PC
    return R[15]; // This includes the offset from AArch32 state
```

## Library pseudocode for aarch32/functions/registers/PCStoreValue

```
// PCStoreValue()
// =====

bits(32) PCStoreValue()
    // This function returns the PC value. On architecture versions before Armv7, it
    // is permitted to instead return PC+4, provided it does so consistently. It is
    // used only to describe A32 instructions, so it returns the address of the current
    // instruction plus 8 (normally) or 12 (when the alternative is permitted).
    return PC;
```

## Library pseudocode for aarch32/functions/registers/Q

```
// Q[] - non-assignment form
// =====

bits(128) Q[integer n]
    assert n >= 0 && n <= 15;
    return V[n];

// Q[] - assignment form
// =====

Q[integer n] = bits(128) value
    assert n >= 0 && n <= 15;
    V[n] = value;
    return;
```

## Library pseudocode for aarch32/functions/registers/Qin

```
// Qin[] - non-assignment form
// =====

bits(128) Qin[integer n]
    assert n >= 0 && n <= 15;
    return Din[2*n+1]:Din[2*n];
```

## Library pseudocode for aarch32/functions/registers/R

```
// R[] - assignment form
// =====

R[integer n] = bits(32) value
    Rmode[n, PSTATE.M] = value;
    return;

// R[] - non-assignment form
// =====

bits(32) R[integer n]
    if n == 15 then
        offset = (if CurrentInstrSet() == InstrSet\_A32 then 8 else 4);
        return _PC<31:0> + offset;
    else
        return Rmode[n, PSTATE.M];
```

## Library pseudocode for aarch32/functions/registers/RBankSelect

```
// RBankSelect()
// =====

integer RBankSelect(bits(5) mode, integer usr, integer fiq, integer irq,
                    integer svc, integer abt, integer und, integer hyp)

    case mode of
        when M32\_User      result = usr;    // User mode
        when M32\_FIQ      result = fiq;    // FIQ mode
        when M32\_IRQ      result = irq;    // IRQ mode
        when M32\_Svc      result = svc;    // Supervisor mode
        when M32\_Abort     result = abt;    // Abort mode
        when M32\_Hyp       result = hyp;    // Hyp mode
        when M32\_Undef     result = und;    // Undefined mode
        when M32\_System    result = usr;    // System mode uses User mode registers
        otherwise          Unreachable(); // Monitor mode

    return result;
```

## Library pseudocode for aarch32/functions/registers/Rmode

```
// Rmode[] - non-assignment form
// =====

bits(32) Rmode[integer n, bits(5) mode]
    assert n >= 0 && n <= 14;

    // Check for attempted use of Monitor mode in Non-secure state.
    if !IsSecure() then assert mode != M32_Monitor;
    assert !BadMode(mode);

    if mode == M32_Monitor then
        if n == 13 then return SP_mon;
        elsif n == 14 then return LR_mon;
        else return _R[n]<31:0>;
    else
        return _R[LookupRIndex(n, mode)]<31:0>;

// Rmode[] - assignment form
// =====

Rmode[integer n, bits(5) mode] = bits(32) value
    assert n >= 0 && n <= 14;

    // Check for attempted use of Monitor mode in Non-secure state.
    if !IsSecure() then assert mode != M32_Monitor;
    assert !BadMode(mode);

    if mode == M32_Monitor then
        if n == 13 then SP_mon = value;
        elsif n == 14 then LR_mon = value;
        else _R[n]<31:0> = value;
    else
        // It is CONSTRAINED UNPREDICTABLE whether the upper 32 bits of the X
        // register are unchanged or set to zero. This is also tested for on
        // exception entry, as this applies to all AArch32 registers.
        if !HighestELUsingAArch32() && ConstrainUnpredictableBool(Unpredictable_ZEROUPPER) then
            _R[LookupRIndex(n, mode)] = ZeroExtend(value);
        else
            _R[LookupRIndex(n, mode)]<31:0> = value;

    return;
```

## Library pseudocode for aarch32/functions/registers/S

```
// S[] - non-assignment form
// =====

bits(32) S[integer n]
    assert n >= 0 && n <= 31;
    base = (n MOD 4) * 32;
    bits(128) vreg = V[n DIV 4];
    return vreg<base+31:base>;

// S[] - assignment form
// =====

S[integer n] = bits(32) value
    assert n >= 0 && n <= 31;
    base = (n MOD 4) * 32;
    bits(128) vreg = V[n DIV 4];
    vreg<base+31:base> = value;
    V[n DIV 4] = vreg;
    return;
```

## Library pseudocode for aarch32/functions/registers/SP

```
// SP - assignment form
// =====

SP = bits(32) value
  R[13] = value;
  return;

// SP - non-assignment form
// =====

bits(32) SP
  return R[13];
```

## Library pseudocode for aarch32/functions/registers/\_Dclone

```
array bits(64) _Dclone[0..31];
```

## Library pseudocode for aarch32/functions/system/AArch32.ExceptionReturn

```
// AArch32.ExceptionReturn()
// =====

AArch32.ExceptionReturn(bits(32) new_pc, bits(32) spsr)

  SynchronizeContext();
  // Attempts to change to an illegal mode or state will invoke the Illegal Execution state
  // mechanism
  SetPSTATEFromPSR(spsr);
  ClearExclusiveLocal(ProcessorID());
  SendEventLocal();

  if PSTATE.IL == '1' then
    // If the exception return is illegal, PC[1:0] are UNKNOWN
    new_pc<1:0> = bits(2) UNKNOWN;
  else
    // LR[1:0] or LR[0] are treated as being 0, depending on the target instruction set state
    if PSTATE.T == '1' then
      new_pc<0> = '0'; // T32
    else
      new_pc<1:0> = '00'; // A32

  boolean branch_conditional = AArch32.CurrentCond() != '111x';
  BranchTo(new_pc, BranchType_ERET, branch_conditional);
```

## Library pseudocode for aarch32/functions/system/AArch32.ExecutingCP10or11Instr

```
// AArch32.ExecutingCP10or11Instr()
// =====

boolean AArch32.ExecutingCP10or11Instr()
  instr = ThisInstr();
  instr_set = CurrentInstrSet();
  assert instr_set IN {InstrSet_A32, InstrSet_T32};

  if instr_set == InstrSet_A32 then
    return ((instr<27:24> == '1110' || instr<27:25> == '110') && instr<11:8> == '101x');
  else // InstrSet_T32
    return (instr<31:28> == '111x' && (instr<27:24> == '1110' || instr<27:25> == '110') && instr<11:8> == '101x');
```

### Library pseudocode for aarch32/functions/system/AArch32.ITAdvance

```
// AArch32.ITAdvance()
// =====

AArch32.ITAdvance()
  if PSTATE.IT<2:0> == '000' then
    PSTATE.IT = '00000000';
  else
    PSTATE.IT<4:0> = LSL(PSTATE.IT<4:0>, 1);
  return;
```

### Library pseudocode for aarch32/functions/system/AArch32.SysRegRead

```
// Read from a 32-bit AArch32 System register and return the register's contents.
bits(32) AArch32.SysRegRead(integer cp_num, bits(32) instr);
```

### Library pseudocode for aarch32/functions/system/AArch32.SysRegRead64

```
// Read from a 64-bit AArch32 System register and return the register's contents.
bits(64) AArch32.SysRegRead64(integer cp_num, bits(32) instr);
```

### Library pseudocode for aarch32/functions/system/AArch32.SysRegReadCanWriteAPSR

```
// AArch32.SysRegReadCanWriteAPSR()
// =====
// Determines whether the AArch32 System register read instruction can write to APSR flags.

boolean AArch32.SysRegReadCanWriteAPSR(integer cp_num, bits(32) instr)
  assert UsingAArch32();
  assert (cp_num IN {14,15});
  assert cp_num == UInt(instr<11:8>);

  opc1 = UInt(instr<23:21>);
  opc2 = UInt(instr<7:5>);
  CRn = UInt(instr<19:16>);
  CRm = UInt(instr<3:0>);

  if cp_num == 14 && opc1 == 0 && CRn == 0 && CRm == 1 && opc2 == 0 then // DBGDSCRint
    return TRUE;

  return FALSE;
```

### Library pseudocode for aarch32/functions/system/AArch32.SysRegWrite

```
// Write to a 32-bit AArch32 System register.
AArch32.SysRegWrite(integer cp_num, bits(32) instr, bits(32) val);
```

### Library pseudocode for aarch32/functions/system/AArch32.SysRegWrite64

```
// Write to a 64-bit AArch32 System register.
AArch32.SysRegWrite64(integer cp_num, bits(32) instr, bits(64) val);
```

### Library pseudocode for aarch32/functions/system/AArch32.SysRegWriteM

```
// Read a value from a virtual address and write it to an AArch32 System register.
AArch32.SysRegWriteM(integer cp_num, bits(32) instr, bits(32) address);
```



## Library pseudocode for aarch32/functions/system/AArch32.WriteMode

```
// AArch32.WriteMode()
// =====
// Function for dealing with writes to PSTATE.M from AArch32 state only.
// This ensures that PSTATE.EL and PSTATE.SP are always valid.

AArch32.WriteMode(bits(5) mode)
    (valid,el) = ELFromM32(mode);
    assert valid;
    PSTATE.M    = mode;
    PSTATE.EL   = el;
    PSTATE.nRW  = '1';
    PSTATE.SP   = (if mode IN {M32\_User,M32\_System} then '0' else '1');
    return;
```

## Library pseudocode for aarch32/functions/system/AArch32.WriteModeByInstr

```
// AArch32.WriteModeByInstr()
// =====
// Function for dealing with writes to PSTATE.M from an AArch32 instruction, and ensuring that
// illegal state changes are correctly flagged in PSTATE.IL.

AArch32.WriteModeByInstr(bits(5) mode)
    (valid,el) = ELFromM32(mode);

    // 'valid' is set to FALSE if 'mode' is invalid for this implementation or the current value
    // of SCR.NS/SCR_EL3.NS. Additionally, it is illegal for an instruction to write 'mode' to
    // PSTATE.EL if it would result in any of:
    // * A change to a mode that would cause entry to a higher Exception level.
    if UInt(el) > UInt(PSTATE.EL) then
        valid = FALSE;

    // * A change to or from Hyp mode.
    if (PSTATE.M == M32\_Hyp || mode == M32\_Hyp) && PSTATE.M != mode then
        valid = FALSE;

    // * When EL2 is implemented, the value of HCR.TGE is '1', a change to a Non-secure EL1 mode.
    if PSTATE.M == M32\_Monitor && HaveEL(EL2) && el == EL1 && SCR.NS == '1' && HCR.TGE == '1' then
        valid = FALSE;

    if !valid then
        PSTATE.IL = '1';
    else
        AArch32.WriteMode(mode);
```

## Library pseudocode for aarch32/functions/system/BadMode

```
// BadMode()
// =====

boolean BadMode(bits(5) mode)
// Return TRUE if 'mode' encodes a mode that is not valid for this implementation
case mode of
  when M32\_Monitor
    valid = HaveAArch32EL\(EL3\);
  when M32\_Hyp
    valid = HaveAArch32EL\(EL2\);
  when M32\_FIQ, M32\_IRQ, M32\_Svc, M32\_Abort, M32\_Undef, M32\_System
    // If EL3 is implemented and using AArch32, then these modes are EL3 modes in Secure
    // state, and EL1 modes in Non-secure state. If EL3 is not implemented or is using
    // AArch64, then these modes are EL1 modes.
    // Therefore it is sufficient to test this implementation supports EL1 using AArch32.
    valid = HaveAArch32EL\(EL1\);
  when M32\_User
    valid = HaveAArch32EL\(EL0\);
  otherwise
    valid = FALSE;          // Passed an illegal mode value
return !valid;
```

## Library pseudocode for aarch32/functions/system/BankedRegisterAccessValid

```
// BankedRegisterAccessValid()
// =====
// Checks for MRS (Banked register) or MSR (Banked register) accesses to registers
// other than the SPSRs that are invalid. This includes ELR_hyp accesses.

BankedRegisterAccessValid(bits(5) SYSm, bits(5) mode)

case SYSm of
  when '000xx', '00100' // R8_usr to R12_usr
    if mode != M32\_FIQ then UNPREDICTABLE;
  when '00101' // SP_usr
    if mode == M32\_System then UNPREDICTABLE;
  when '00110' // LR_usr
    if mode IN {M32\_Hyp,M32\_System} then UNPREDICTABLE;
  when '010xx', '0110x', '01110' // R8_fiq to R12_fiq, SP_fiq, LR_fiq
    if mode == M32\_FIQ then UNPREDICTABLE;
  when '1000x' // LR_irq, SP_irq
    if mode == M32\_IRQ then UNPREDICTABLE;
  when '1001x' // LR_svc, SP_svc
    if mode == M32\_Svc then UNPREDICTABLE;
  when '1010x' // LR_abt, SP_abt
    if mode == M32\_Abort then UNPREDICTABLE;
  when '1011x' // LR_und, SP_und
    if mode == M32\_Undef then UNPREDICTABLE;
  when '1110x' // LR_mon, SP_mon
    if !HaveEL\(EL3\) || !IsSecure\(\) || mode == M32\_Monitor then UNPREDICTABLE;
  when '11110' // ELR_hyp, only from Monitor or Hyp mode
    if !HaveEL\(EL2\) || !(mode IN {M32\_Monitor,M32\_Hyp}) then UNPREDICTABLE;
  when '11111' // SP_hyp, only from Monitor mode
    if !HaveEL\(EL2\) || mode != M32\_Monitor then UNPREDICTABLE;
  otherwise
    UNPREDICTABLE;

return;
```

## Library pseudocode for aarch32/functions/system/CPSRWriteByInstr

```
// CPSRWriteByInstr()
// =====
// Update PSTATE.<N,Z,C,V,Q,GE,E,A,I,F,M> from a CPSR value written by an MSR instruction.

CPSRWriteByInstr(bits(32) value, bits(4) bytemask)
    privileged = PSTATE.EL != EL0;          // PSTATE.<A,I,F,M> are not writable at EL0

    // Write PSTATE from 'value', ignoring bytes masked by 'bytemask'
    if bytemask<3> == '1' then
        PSTATE.<N,Z,C,V,Q> = value<31:27>;
        // Bits <26:24> are ignored

    if bytemask<2> == '1' then
        if HaveSSBSExt() then
            PSTATE.SSBS = value<23>;
        if privileged then
            PSTATE.PAN = value<22>;
        if HaveDITExt() then
            PSTATE.DIT = value<21>;
        // Bit <20> is RES0
        PSTATE.GE = value<19:16>;

    if bytemask<1> == '1' then
        // Bits <15:10> are RES0
        PSTATE.E = value<9>;                // PSTATE.E is writable at EL0
        if privileged then
            PSTATE.A = value<8>;

    if bytemask<0> == '1' then
        if privileged then
            PSTATE.<I,F> = value<7:6>;
            // Bit <5> is RES0
            // AArch32.WriteModeByInstr() sets PSTATE.IL to 1 if this is an illegal mode change.
            AArch32.WriteModeByInstr(value<4:0>);
    return;
```

## Library pseudocode for aarch32/functions/system/ConditionPassed

```
// ConditionPassed()
// =====

boolean ConditionPassed()
    return ConditionHolds(AArch32.CurrentCond());
```

## Library pseudocode for aarch32/functions/system/CurrentCond

```
bits(4) AArch32.CurrentCond();
```

## Library pseudocode for aarch32/functions/system/InITBlock

```
// InITBlock()
// =====

boolean InITBlock()
    if CurrentInstrSet() == InstrSet\_T32 then
        return PSTATE.IT<3:0> != '0000';
    else
        return FALSE;
```

## Library pseudocode for aarch32/functions/system/LastInITBlock

```
// LastInITBlock()
// =====

boolean LastInITBlock()
    return (PSTATE.IT<3:0> == '1000');
```

## Library pseudocode for aarch32/functions/system/SPSRWriteByInstr

```
// SPSRWriteByInstr()
// =====

SPSRWriteByInstr(bits(32) value, bits(4) bytemask)

    bits(32) new_spsr = SPSR[];

    if bytemask<3> == '1' then
        new_spsr<31:24> = value<31:24>; // N,Z,C,V,Q flags, IT[1:0],J bits

    if bytemask<2> == '1' then
        new_spsr<23:16> = value<23:16>; // IL bit, GE[3:0] flags

    if bytemask<1> == '1' then
        new_spsr<15:8> = value<15:8>; // IT[7:2] bits, E bit, A interrupt mask

    if bytemask<0> == '1' then
        new_spsr<7:0> = value<7:0>; // I,F interrupt masks, T bit, Mode bits

    SPSR[] = new_spsr; // UNPREDICTABLE if User or System mode

    return;
```

## Library pseudocode for aarch32/functions/system/SPSRAccessValid

```
// SPSRAccessValid()
// =====
// Checks for MRS (Banked register) or MSR (Banked register) accesses to the SPSRs
// that are UNPREDICTABLE

SPSRAccessValid(bits(5) SYSm, bits(5) mode)
    case SYSm of
        when '01110' // SPSR_fiq
            if mode == M32_FIQ then UNPREDICTABLE;
        when '10000' // SPSR_irq
            if mode == M32_IRQ then UNPREDICTABLE;
        when '10010' // SPSR_svc
            if mode == M32_Svc then UNPREDICTABLE;
        when '10100' // SPSR_abt
            if mode == M32_Abort then UNPREDICTABLE;
        when '10110' // SPSR_und
            if mode == M32_Undef then UNPREDICTABLE;
        when '11100' // SPSR_mon
            if !HaveEL(EL3) || mode == M32_Monitor || !IsSecure() then UNPREDICTABLE;
        when '11110' // SPSR_hyp
            if !HaveEL(EL2) || mode != M32_Monitor then UNPREDICTABLE;
        otherwise
            UNPREDICTABLE;

    return;
```

## Library pseudocode for aarch32/functions/system/SelectInstrSet

```
// SelectInstrSet()
// =====

SelectInstrSet(InstrSet iset)
    assert CurrentInstrSet() IN {InstrSet\_A32, InstrSet\_T32};
    assert iset IN {InstrSet\_A32, InstrSet\_T32};

    PSTATE.T = if iset == InstrSet\_A32 then '0' else '1';

    return;
```

## Library pseudocode for aarch32/functions/v6simd/Sat

```
// Sat()
// =====

bits(N) Sat(integer i, integer N, boolean unsigned)
    result = if unsigned then UnsignedSat(i, N) else SignedSat(i, N);
    return result;
```

## Library pseudocode for aarch32/functions/v6simd/SignedSat

```
// SignedSat()
// =====

bits(N) SignedSat(integer i, integer N)
    (result, -) = SignedSat0(i, N);
    return result;
```

## Library pseudocode for aarch32/functions/v6simd/UnsignedSat

```
// UnsignedSat()
// =====

bits(N) UnsignedSat(integer i, integer N)
    (result, -) = UnsignedSat0(i, N);
    return result;
```



```

// AArch32.DefaultTEXDecode()
// =====
// Apply short-descriptor format memory region attributes, without TEX remap

MemoryAttributes AArch32.DefaultTEXDecode(bits(3) TEX, bit C, bit B, bit S)
    MemoryAttributes memattrs;

// Reserved values map to allocated values
if (TEX == '001' && C:B == '01') || (TEX == '010' && C:B != '00') || TEX == '011' then
    bits(5) texcb;
    (-, texcb) = ConstrainUnpredictableBits(Unpredictable\_RESTEXCB);
    TEX = texcb<4:2>; C = texcb<1>; B = texcb<0>;

// Distinction between Inner Shareable and Outer Shareable is not supported in this format
// A memory region is either Non-shareable or Outer Shareable
case TEX:C:B of
    when '00000'
        // Device-nGnRnE
        memattrs.memtype = MemType\_Device;
        memattrs.device = DeviceType\_nGnRnE;
        memattrs.shareability = Shareability\_OSH;
    when '00001', '01000'
        // Device-nGnRE
        memattrs.memtype = MemType\_Device;
        memattrs.device = DeviceType\_nGnRE;
        memattrs.shareability = Shareability\_OSH;
    when '00010'
        // Write-through Read allocate
        memattrs.memtype = MemType\_Normal;
        memattrs.inner.attrs = MemAttr\_WT;
        memattrs.inner.hints = MemHint\_RA;
        memattrs.outer.attrs = MemAttr\_WT;
        memattrs.outer.hints = MemHint\_RA;
        memattrs.shareability = if S == '1' then Shareability\_OSH else Shareability\_NSH;
    when '00011'
        // Write-back Read allocate
        memattrs.memtype = MemType\_Normal;
        memattrs.inner.attrs = MemAttr\_WB;
        memattrs.inner.hints = MemHint\_RA;
        memattrs.outer.attrs = MemAttr\_WB;
        memattrs.outer.hints = MemHint\_RA;
        memattrs.shareability = if S == '1' then Shareability\_OSH else Shareability\_NSH;
    when '00100'
        // Non-cacheable
        memattrs.memtype = MemType\_Normal;
        memattrs.inner.attrs = MemAttr\_NC;
        memattrs.outer.attrs = MemAttr\_NC;
        memattrs.shareability = Shareability\_OSH;
    when '00110'
        memattrs = MemoryAttributes IMPLEMENTATION_DEFINED;
    when '00111'
        // Write-back Read and Write allocate
        memattrs.memtype = MemType\_Normal;
        memattrs.inner.attrs = MemAttr\_WB;
        memattrs.inner.hints = MemHint\_RWA;
        memattrs.outer.attrs = MemAttr\_WB;
        memattrs.outer.hints = MemHint\_RWA;
        memattrs.shareability = if S == '1' then Shareability\_OSH else Shareability\_NSH;
    when '1xxxx'
        // Cacheable, TEX<1:0> = Outer attrs, {C,B} = Inner attrs
        memattrs.memtype = MemType\_Normal;
        memattrs.inner = DecodeSDFAttr(C:B);
        memattrs.outer = DecodeSDFAttr(TEX<1:0>);

        if memattrs.inner.attrs == MemAttr\_NC && memattrs.outer.attrs == MemAttr\_NC then
            memattrs.shareability = Shareability\_OSH;
        else
            memattrs.shareability = if S == '1' then Shareability\_OSH else Shareability\_NSH;
    otherwise
        // Reserved, handled above

```

```
    Unreachable\(\);  
  
    // The Transient hint is not supported in this format  
    memattrs.inner.transient = FALSE;  
    memattrs.outer.transient = FALSE;  
    memattrs.tagged          = FALSE;  
  
    if memattrs.inner.attrs == MemAttr\_WB && memattrs.outer.attrs == MemAttr\_WB then  
        memattrs.xs = '0';  
    else  
        memattrs.xs = '1';  
  
    return memattrs;
```



## Library pseudocode for aarch32/translation/attrs/AArch32.RemappedTEXDecode

```
// AArch32.RemappedTEXDecode()
// =====
// Apply short-descriptor format memory region attributes, with TEX remap

MemoryAttributes AArch32.RemappedTEXDecode(bits(3) TEX, bit C, bit B, bit S)

    MemoryAttributes memattrs;

    region = UInt(TEX<0>:C:B);          // TEX<2:1> are ignored in this mapping scheme
    if region == 6 then
        return MemoryAttributes IMPLEMENTATION_DEFINED;

    base = 2 * region;
    attrfield = PRRR<base+1:base>;

    if attrfield == '11' then          // Reserved, maps to allocated value
        (-, attrfield) = ConstrainUnpredictableBits(Unpredictable_RESRRR);

    case attrfield of
        when '00'                    // Device-nGnRnE
            memattrs.memtype          = MemType_Device;
            memattrs.device            = DeviceType_nGnRnE;
            memattrs.shareability     = Shareability_OSH;
        when '01'                    // Device-nGnRE
            memattrs.memtype          = MemType_Device;
            memattrs.device            = DeviceType_nGnRE;
            memattrs.shareability     = Shareability_OSH;
        when '10'
            NSn = if S == '0' then PRRR.NS0 else PRRR.NS1;
            NOSm = PRRR<region+24> AND NSn;
            IRn = NMRR<base+1:base>;
            ORn = NMRR<base+17:base+16>;

            memattrs.memtype = MemType_Normal;
            memattrs.inner   = DecodeSDFAttr(IRn);
            memattrs.outer   = DecodeSDFAttr(ORn);
            if memattrs.inner.attrs == MemAttr_NC && memattrs.outer.attrs == MemAttr_NC then
                memattrs.shareability = Shareability_OSH;
            else
                memattrs.shareability = DecodeShareability(<NSn:NOSm>);
        when '11'
            Unreachable();

    // The Transient hint is not supported in this format
    memattrs.inner.transient = FALSE;
    memattrs.outer.transient = FALSE;
    memattrs.tagged          = FALSE;

    if memattrs.inner.attrs == MemAttr_WB && memattrs.outer.attrs == MemAttr_WB then
        memattrs.xs = '0';
    else
        memattrs.xs = '1';

    return memattrs;
```

## Library pseudocode for aarch32/translation/debug/AArch32.CheckBreakpoint

```
// AArch32.CheckBreakpoint()
// =====
// Called before executing the instruction of length "size" bytes at "vaddress" in an AArch32
// translation regime, when either debug exceptions are enabled, or halting debug is enabled
// and halting is allowed.

FaultRecord AArch32.CheckBreakpoint(bits(32) vaddress, integer size)
    assert ELUsingAArch32\(S1TranslationRegime\(\)\);
    assert size IN {2,4};

    match = FALSE;
    mismatch = FALSE;

    for i = 0 to UInt\(DBGDIDR.BRPs\)
        (match_i, mismatch_i) = AArch32.BreakpointMatch(i, vaddress, size);
        match = match || match_i;
        mismatch = mismatch || mismatch_i;

    if match && HaltOnBreakpointOrWatchpoint\(\) then
        reason = DebugHalt\_Breakpoint;
        Halt(reason);
    elseif (match || mismatch) then
        acctype = AccType\_IFETCH;
        iswrite = FALSE;
        debugmoe = DebugException\_Breakpoint;
        return AArch32.DebugFault(acctype, iswrite, debugmoe);
    else
        return NoFault();
```

## Library pseudocode for aarch32/translation/debug/AArch32.CheckDebug

```
// AArch32.CheckDebug()
// =====
// Called on each access to check for a debug exception or entry to Debug state.

FaultRecord AArch32.CheckDebug(bits(32) vaddress, AccType acctype, boolean iswrite, integer size)

    FaultRecord fault = NoFault();

    d_side = (acctype != AccType\_IFETCH);
    generate_exception = AArch32.GenerateDebugExceptions\(\) && DBGDSCRext.MDBGGen == '1';
    halt = HaltOnBreakpointOrWatchpoint\(\);
    // Relative priority of Vector Catch and Breakpoint exceptions not defined in the architecture
    vector_catch_first = ConstrainUnpredictableBool\(Unpredictable\_BPVECTORCATCHPRI\);

    if !d_side && vector_catch_first && generate_exception then
        fault = AArch32.CheckVectorCatch(vaddress, size);

    if fault.statuscode == Fault\_None && (generate_exception || halt) then
        if d_side then
            fault = AArch32.CheckWatchpoint(vaddress, acctype, iswrite, size);
        else
            fault = AArch32.CheckBreakpoint(vaddress, size);

    if fault.statuscode == Fault\_None && !d_side && !vector_catch_first && generate_exception then
        return AArch32.CheckVectorCatch(vaddress, size);

    return fault;
```

## Library pseudocode for aarch32/translation/debug/AArch32.CheckVectorCatch

```
// AArch32.CheckVectorCatch()
// =====
// Called before executing the instruction of length "size" bytes at "vaddress" in an AArch32
// translation regime, when debug exceptions are enabled.

FaultRecord AArch32.CheckVectorCatch(bits(32) vaddress, integer size)
    assert ELUsingAArch32(S1TranslationRegime());

    match = AArch32.VCRMATCH(vaddress);
    if size == 4 && !match && AArch32.VCRMATCH(vaddress + 2) then
        match = ConstrainUnpredictableBool(Unpredictable_VCMATCHHALF);

    if match then
        acctype = AccType_IFETCH;
        iswrite = FALSE;
        debugmoe = DebugException_VectorCatch;
        return AArch32.DebugFault(acctype, iswrite, debugmoe);
    else
        return NoFault();
```

## Library pseudocode for aarch32/translation/debug/AArch32.CheckWatchpoint

```
// AArch32.CheckWatchpoint()
// =====
// Called before accessing the memory location of "size" bytes at "address",
// when either debug exceptions are enabled for the access, or halting debug
// is enabled and halting is allowed.

FaultRecord AArch32.CheckWatchpoint(bits(32) vaddress, AccType acctype,
                                     boolean iswrite, integer size)
    assert ELUsingAArch32(S1TranslationRegime());

    if acctype IN {AccType_TTW, AccType_IC, AccType_AT, AccType_ATPAN} then
        return NoFault();
    if acctype == AccType_DC then
        if !iswrite then
            return NoFault();
        elsif !(boolean IMPLEMENTATION_DEFINED "DCIMVAC generates watchpoint") then
            return NoFault();

    match = FALSE;
    ispriv = AArch32.AccessUsesEL(acctype) != EL0;

    for i = 0 to UInt(DBGDIDR.WRPs)
        if AArch32.WatchpointMatch(i, vaddress, size, ispriv, acctype, iswrite) then
            match = TRUE;

    if match && HaltOnBreakpointOrWatchpoint() then
        reason = DebugHalt_Watchpoint;
        EDWAR = ZeroExtend(vaddress);
        Halt(reason);
    elsif match then
        debugmoe = DebugException_Watchpoint;
        return AArch32.DebugFault(acctype, iswrite, debugmoe);
    else
        return NoFault();
```

## Library pseudocode for aarch32/translation/faults/AArch32.DebugFault

```
// AArch32.DebugFault()
// =====
// Return a fault record indicating a hardware watchpoint/breakpoint

FaultRecord AArch32.DebugFault(AccType acctype, boolean iswrite, bits(4) debugmoe)
    FaultRecord fault;

    fault.statuscode = Fault_Debug;
    fault.acctype     = acctype;
    fault.write       = iswrite;
    fault.debugmoe    = debugmoe;
    fault.secondstage = FALSE;
    fault.s2fslwalk   = FALSE;

    return fault;
```

## Library pseudocode for aarch32/translation/faults/AArch32.IPAIsOutOfRange

```
// AArch32.IPAIsOutOfRange()
// =====
// Check intermediate physical address bits not resolved by translation are ZERO

boolean AArch32.IPAIsOutOfRange(S2TTWParams walkparams, bits(40) ipa)
    // Input Address size
    iasize = AArch32.S2IASize(walkparams.t0sz);

    return iasize < 40 && !IsZero(ipa<39:iasize>);
```

## Library pseudocode for aarch32/translation/faults/AArch32.S1HasAlignmentFault

```
// AArch32.S1HasAlignmentFault()
// =====
// Returns whether stage 1 output fails alignment requirement on data accesses
// to Device memory

boolean AArch32.S1HasAlignmentFault(AccType acctype, boolean aligned,
                                     bit ntlsmid, MemoryAttributes memattrs)
    if acctype == AccType_IFETCH || memattrs.memtype != MemType_Device then
        return FALSE;

    if acctype == AccType_A32LSMD && ntlsmid == '0' && memattrs.device != DeviceType_GRE then
        return TRUE;

    return !aligned || acctype == AccType_DCZVA;
```



```

// AArch32.S1LDHasPermissionsFault()
// =====
// Returns whether an access using stage 1 long-descriptor translation
// violates permissions of target memory

boolean AArch32.S1LDHasPermissionsFault(Regime regime, S1TTWParams walkparams,
                                         Permissions perms, MemType memtype,
                                         PASpace paspace, boolean ispriv,
                                         AccType acctype, boolean iswrite)

if HasUnprivileged(regime) then
    // Apply leaf permissions
    case perms.ap<2:1> of
        when '00' (pr,pw,ur,uw) = ('1','1','0','0'); // R/W at PL1 only
        when '01' (pr,pw,ur,uw) = ('1','1','1','1'); // R/W at any PL
        when '10' (pr,pw,ur,uw) = ('1','0','0','0'); // R0 at PL1 only
        when '11' (pr,pw,ur,uw) = ('1','0','1','0'); // R0 at any PL

    // Apply hierarchical permissions
    case perms.ap_table of
        when '00' (pr,pw,ur,uw) = ( pr, pw, ur, uw); // No effect
        when '01' (pr,pw,ur,uw) = ( pr, pw, '0','0'); // Privileged access
        when '10' (pr,pw,ur,uw) = ( pr, '0', ur, '0'); // Read-only
        when '11' (pr,pw,ur,uw) = ( pr, '0', '0','0'); // Read-only, privileged access

    wxn = walkparams.wxn;
    uwxn = walkparams.uwxn;
    xn = perms.xn OR perms.xn_table;
    pxn = perms.pxn OR perms.pxn_table;

    ux = ur AND NOT(xn OR (uw AND wxn));
    px = pr AND NOT(xn OR pxn OR (pw AND wxn) OR (uw AND uwxn));

    pan_access = !(acctype IN {AccType\_DC, AccType\_IFETCH, AccType\_AT});
    if HavePANExt() && pan_access then
        pan = PSTATE.PAN AND (ur OR uw);
        pr = pr AND NOT(pan);
        pw = pw AND NOT(pan);

    (r,w,x) = if ispriv then (pr,pw,px) else (ur,uw,ux);

    // Prevent execution from Non-secure space by PE in Secure state if SIF is set
    if IsSecure() && paspace == PAS_NonSecure then
        x = x AND NOT(walkparams.sif);
else
    // Apply leaf permissions
    case perms.ap<2> of
        when '0' (r,w) = ('1','1'); // No effect
        when '1' (r,w) = ('1','0'); // Read-only

    // Apply hierarchical permissions
    case perms.ap_table<1> of
        when '0' (r,w) = ( r , w ); // No effect
        when '1' (r,w) = ( r , '0'); // Read-only

    xn = perms.xn OR perms.xn_table;
    x = NOT(xn OR (w AND walkparams.wxn));

if acctype == AccType\_IFETCH then
    constraint = ConstrainUnpredictable(Unpredictable\_INSTRDEVICE);
    if constraint == Constraint\_FAULT && memtype == MemType\_Device then
        return TRUE;
    else
        return x == '0';
elseif acctype IN {AccType\_IC, AccType\_DC} then
    return FALSE;
elseif iswrite then
    return w == '0';
else
    return r == '0';

```

## Library pseudocode for aarch32/translation/faults/AArch32.S1SDHasPermissionsFault

```
// AArch32.S1SDHasPermissionsFault()
// =====
// Returns whether an access using stage 1 short-descriptor translation
// violates permissions of target memory

boolean AArch32.S1SDHasPermissionsFault(Permissions perms, MemType memtype,
                                         PASpace paspace, boolean ispriv,
                                         AccType acctype, boolean iswrite)

wxn = SCTL.R.WXN;
uwxn = SCTL.R.UWXN;
if SCTL.R.AFE == '0' then
    // Map Reserved encoding '100'
    if perms.ap == '100' then
        perms.ap = bits(3) IMPLEMENTATION_DEFINED "Reserved short descriptor AP encoding";

    case perms.ap of
        when '000' (pr,pw,ur,uw) = ('0','0','0','0'); // No access
        when '001' (pr,pw,ur,uw) = ('1','1','0','0'); // R/W at PL1 only
        when '010' (pr,pw,ur,uw) = ('1','1','1','0'); // R/W at PL1, R0 at PL0
        when '011' (pr,pw,ur,uw) = ('1','1','1','1'); // R/W at any PL
        // '100' is reserved
        when '101' (pr,pw,ur,uw) = ('1','0','0','0'); // R0 at PL1 only
        when '110' (pr,pw,ur,uw) = ('1','0','1','0'); // R0 at any PL (deprecated)
        when '111' (pr,pw,ur,uw) = ('1','0','1','0'); // R0 at any PL
    else // Simplified access permissions model
        case perms.ap<2:1> of
            when '00' (pr,pw,ur,uw) = ('1','1','0','0'); // R/W at PL1 only
            when '01' (pr,pw,ur,uw) = ('1','1','1','1'); // R/W at any PL
            when '10' (pr,pw,ur,uw) = ('1','0','0','0'); // R0 at PL1 only
            when '11' (pr,pw,ur,uw) = ('1','0','1','0'); // R0 at any PL

ux = ur AND NOT(perms.xn OR (uw AND wxn));
px = pr AND NOT(perms.xn OR perms.pxn OR (pw AND wxn) OR (uw AND uwxn));

pan_access = !(acctype IN {AccType\_DC, AccType\_IFETCH, AccType\_AT});
if HavePANExt() && pan_access then
    pan = PSTATE.PAN AND (ur OR uw);
    pr = pr AND NOT(pan);
    pw = pw AND NOT(pan);

(r,w,x) = if ispriv then (pr,pw,px) else (ur,uw,ux);

// Prevent execution from Non-secure space by PE in Secure state if SIF is set
if IsSecure() && paspace == PAS_NonSecure then
    x = x AND NOT(if ELUsingAArch32(EL3) then SCR.SIF else SCR_EL3.SIF);

if acctype == AccType\_IFETCH then
    constraint = ConstrainUnpredictable(Unpredictable\_INSTRDEVICE);
    if constraint == Constraint\_FAULT && memtype == MemType\_Device then
        return TRUE;
    else
        return x == '0';
elsif acctype IN {AccType\_IC, AccType\_DC} then
    return FALSE;
elsif iswrite then
    return w == '0';
else
    return r == '0';
```

## Library pseudocode for aarch32/translation/faults/AArch32.S2HasAlignmentFault

```
// AArch32.S2HasAlignmentFault()
// =====
// Returns whether stage 2 output fails alignment requirement on data accesses
// to Device memory

boolean AArch32.S2HasAlignmentFault(AccType acctype, boolean aligned,
                                     MemoryAttributes memattrs)
    if acctype == AccType\_IFETCH || memattrs.memtype != MemType\_Device then
        return FALSE;

    return !aligned || acctype == AccType\_DCZVA;
```

## Library pseudocode for aarch32/translation/faults/AArch32.S2HasPermissionsFault

```
// AArch32.S2HasPermissionsFault()
// =====
// Returns whether stage 2 access violates permissions of target memory

boolean AArch32.S2HasPermissionsFault(boolean s2fslwalk, S2TTWParams walkparams,
                                       Permissions perms, MemType memtype,
                                       boolean ispriv, AccType acctype,
                                       boolean iswrite)

    r = perms.s2ap<0>;
    w = perms.s2ap<1>;
    if HaveExtendedExecuteNeverExt() then
        case perms.s2xn:perms.s2xn of
            when '00' (px, ux) = ( r , r );
            when '01' (px, ux) = ( '0', r );
            when '10' (px, ux) = ( '0', '0' );
            when '11' (px, ux) = ( r , '0' );

        x = if ispriv then px else ux;
    else
        x = r AND NOT(perms.s2xn);

    if s2fslwalk && walkparams.ptw == '1' && memtype == MemType\_Device then
        return TRUE;
    elsif acctype == AccType\_IFETCH then
        constraint = ConstrainUnpredictable(Unpredictable\_INSTRDEVICE);
        if constraint == Constraint\_FAULT && memtype == MemType\_Device then
            return TRUE;
        else
            return x == '0';
    elsif acctype IN {AccType\_IC, AccType\_DC} then
        return FALSE;
    elsif iswrite then
        return w == '0';
    else
        return r == '0';
```



## Library pseudocode for aarch32/translation/faults/AArch32.S2InconsistentSL

```
// AArch32.S2InconsistentSL()
// =====
// Detect inconsistent configuration of stage 2 T0SZ and SL fields

boolean AArch32.S2InconsistentSL(S2TTWParams walkparams)
    startlevel = AArch32.S2StartLevel(walkparams.sl0);
    levels     = FINAL\_LEVEL - startlevel;
    granulebits = TGxGranuleBits(walkparams.tgx);
    stride     = granulebits - 3;

    // Input address size must at least be large enough to be resolved from the start level
    sl_min_iasize = (
        levels * stride // Bits resolved by table walk, except initial level
        + granulebits   // Bits directly mapped to output address
        + 1);           // At least 1 more bit to be decoded by initial level

    // Can accomodate 1 more stride in the level + concatenation of up to 2^4 tables
    sl_max_iasize = sl_min_iasize + (stride-1) + 4;
    // Configured Input Address size
    iasize        = AArch32.S2IASize(walkparams.t0sz);

    return iasize < sl_min_iasize || iasize > sl_max_iasize;
```

## Library pseudocode for aarch32/translation/faults/AArch32.VAIsOutOfRange

```
// AArch32.VAIsOutOfRange()
// =====
// Check virtual address bits not resolved by translation are identical
// and of accepted value

boolean AArch32.VAIsOutOfRange(Regime regime, S1TTWParams walkparams, bits(32) va)
    if regime == Regime\_EL2 then
        // Input Address size
        iasize = AArch32.S1IASize(walkparams.t0sz);
        return walkparams.t0sz != '000' && !IsZero(va<31:iasize>);
    elseif walkparams.t1sz != '000' && walkparams.t0sz != '000' then
        // Lower range Input Address size
        lo_iasize = AArch32.S1IASize(walkparams.t0sz);
        // Upper range Input Address size
        up_iasize = AArch32.S1IASize(walkparams.t1sz);
        return !IsZero(va<31:lo_iasize>) && !IsOnes(va<31:up_iasize>);
    else
        return FALSE;
```

## Library pseudocode for aarch32/translation/translation/AArch32.AccessUsesEL

```
// AArch32.AccessUsesEL()
// =====
// Determine the privilege associated with the access

bits(2) AArch32.AccessUsesEL(AccType acctype)
    if acctype == AccType\_UNPRIV then
        return EL0;
    else
        return PSTATE.EL;
```

## Library pseudocode for aarch32/translation/translation/AArch32.FullTranslate

```
// AArch32.FullTranslate()
// =====
// Perform address translation as specified by VMSA-A32

AddressDescriptor AArch32.FullTranslate(bits(32) va, AccType acctype,
                                       boolean iswrite, boolean aligned)

    // Prepare fault fields in case a fault is detected
    fault = NoFault();
    fault.acctype = acctype;
    fault.write   = iswrite;

    regime = TranslationRegime(PSTATE.EL, acctype);

    // First Stage Translation

    if regime == Regime\_EL2 || TTBCR.EAE == '1' then
        (fault, ipa) = AArch32.S1TranslateLD(fault, regime, va, acctype,
                                             aligned, iswrite);
    else
        (fault, ipa, -) = AArch32.S1TranslateSD(fault, regime, va, acctype,
                                             aligned, iswrite);

    if fault.statuscode != Fault\_None then
        return CreateFaultyAddressDescriptor(ZeroExtend(va), fault);

    if regime == Regime\_EL10 && EL2Enabled() then
        ipa.vaddress = ZeroExtend(va);
        s2fslwalk = FALSE;
        (fault, pa) = AArch32.S2Translate(fault, ipa, s2fslwalk, acctype,
                                         aligned, iswrite);

        if fault.statuscode != Fault\_None then
            return CreateFaultyAddressDescriptor(ZeroExtend(va), fault);
        else
            return pa;
    else
        return ipa;
```

## Library pseudocode for aarch32/translation/translation/AArch32.OutputDomain

```
// AArch32.OutputDomain()
// =====
// Determine the domain the translated output address

bits(2) AArch32.OutputDomain(bits(4) domain)
    index = 2 * UInt(domain);
    Dn = DACR<index+1:index>;

    if Dn == '10' then
        // Reserved value maps to an allocated value
        (-, Dn) = ConstrainUnpredictableBits(Unpredictable\_RESDACR);

    return Dn;
```

## Library pseudocode for aarch32/translation/translation/AArch32.S1DisabledOutput

```
// AArch32.S1DisabledOutput()
// =====
// Flat map the VA to IPA/PA, depending on the regime, assigning default memory attributes
(FaultRecord, AddressDescriptor) AArch32.S1DisabledOutput(FaultRecord fault,
    Regime regime, bits(32) va, AccType acctype, boolean aligned)

    // No memory page is guarded when stage 1 address translation is disabled
    SetInGuardedPage(FALSE);

    MemoryAttributes memattrs;
    if regime == Regime\_EL10 && EL2Enabled() then
        default_cacheable = if ELUsingAArch32(EL2) then HCR.DC else HCR_EL2.DC;
    else
        default_cacheable = '0';

    if default_cacheable == '1' then
        // Use default cacheable settings
        memattrs.memtype = MemType\_Normal;
        memattrs.inner.attrs = MemAttr\_WB;
        memattrs.inner.hints = MemHint\_RWA;
        memattrs.outer.attrs = MemAttr\_WB;
        memattrs.outer.hints = MemHint\_RWA;
        memattrs.shareability = Shareability\_NSH;
        if !ELUsingAArch32(EL2) && HaveMTE2Ext() then
            memattrs.tagged = HCR_EL2.DCT == '1';
        else
            memattrs.tagged = FALSE;
    elseif acctype == AccType\_IFETCH then
        // Instruction cacheability controlled by SCTLR/HSCTLR.I
        icache_en = if regime == Regime\_EL2 then HSCTLR.I else SCTLR.I;

        memattrs.memtype = MemType\_Normal;
        memattrs.shareability = Shareability\_OSH;
        memattrs.tagged = FALSE;
        if icache_en == '1' then
            memattrs.inner.attrs = MemAttr\_WT;
            memattrs.inner.hints = MemHint\_RA;
            memattrs.outer.attrs = MemAttr\_WT;
            memattrs.outer.hints = MemHint\_RA;
        else
            memattrs.inner.attrs = MemAttr\_NC;
            memattrs.outer.attrs = MemAttr\_NC;
    else
        // Treat memory region as Device
        memattrs.memtype = MemType\_Device;
        memattrs.device = DeviceType\_nGnRnE;
        memattrs.shareability = Shareability\_OSH;
        memattrs.tagged = FALSE;

    if HaveTrapLoadStoreMultipleDeviceExt() then
        ntlsmd = if regime == Regime\_EL2 then HSCTLR.nTLSMD else SCTLR.nTLSMD;
    else
        ntlsmd = '1';

    if AArch32.S1HasAlignmentFault(acctype, aligned, ntlsmd, memattrs) then
        fault.statuscode = Fault\_Alignment;
        return (fault, AddressDescriptor UNKNOWN);

    FullAddress oa;
    oa.address = ZeroExtend(va);
    oa.paspace = if IsSecure() then PAS_Secure else PAS_NonSecure;
    ipa = CreateAddressDescriptor(ZeroExtend(va), oa, memattrs);

    return (fault, ipa);
```

## Library pseudocode for aarch32/translation/translation/AArch32.S1Enabled

```
// AArch32.S1Enabled()
// =====
// Returns whether stage 1 translation is enabled for the active translation regime

boolean AArch32.S1Enabled(Regime regime)
    if regime == Regime_EL2 then
        return HSCTLR.M == '1';
    elsif regime == Regime_EL30 || !EL2Enabled() then
        return SCTLR.M == '1';
    elsif ELUsingAArch32(EL2) then
        return HCR.<TGE,DC> == '00' && SCTLR.M == '1';
    else
        return HCR_EL2.<TGE,DC> == '00' && SCTLR.M == '1';
```



```

// AArch32.S1TranslateLD()
// =====
// Perform a stage 1 translation using long-descriptor format mapping VA to IPA/PA
// depending on the regime

(FaultRecord, AddressDescriptor) AArch32.S1TranslateLD(FaultRecord fault,
    Regime regime, bits(32) va, AccType acctype, boolean aligned, boolean iswrite)

    fault.secondstage = FALSE;
    fault.s2fslwalk = FALSE;

    if !AArch32.S1Enabled(regime) then
        return AArch32.S1DisabledOutput(fault, regime, va, acctype, aligned);

    walkparams = AArch32.GetS1TTWParams(regime, va);

    if AArch32.VAIsOutOfRange(regime, walkparams, va) then
        fault.level = 1;
        fault.statuscode = Fault_Translation;
        return (fault, AddressDescriptor UNKNOWN);

    (fault, walkstate) = AArch32.S1WalkLD(fault, regime, walkparams, va);

    if fault.statuscode != Fault_None then
        return (fault, AddressDescriptor UNKNOWN);

    ispriv = AArch32.AccessUsesEL(acctype) != EL0;
    SetInGuardedPage(FALSE); // AArch32-VMVA does not guard any pages

    if AArch32.S1HasAlignmentFault(acctype, aligned, walkparams.ntlsmid,
        walkstate.memattrs) then
        fault.statuscode = Fault_Alignment;
    elseif IsAtomicRW(acctype) then
        if AArch32.S1LDHasPermissionsFault(regime, walkparams,
            walkstate.permissions,
            walkstate.memattrs.memtype,
            walkstate.baseaddress.paspace,
            ispriv, acctype, FALSE) then
            // The permission fault was not caused by lack of write permissions
            fault.statuscode = Fault_Permission;
            fault.write = FALSE;
        elseif AArch32.S1LDHasPermissionsFault(regime, walkparams,
            walkstate.permissions,
            walkstate.memattrs.memtype,
            walkstate.baseaddress.paspace,
            ispriv, acctype, TRUE) then
            // The permission fault _was_ caused by lack of write permissions
            fault.statuscode = Fault_Permission;
            fault.write = TRUE;
    elseif AArch32.S1LDHasPermissionsFault(regime, walkparams,
        walkstate.permissions,
        walkstate.memattrs.memtype,
        walkstate.baseaddress.paspace,
        ispriv, acctype, iswrite) then
        fault.statuscode = Fault_Permission;

    if fault.statuscode != Fault_None then
        return (fault, AddressDescriptor UNKNOWN);

    icache_en = if regime == Regime_EL2 then HSCTLR.I else SCTLR.I;
    dcache_en = if regime == Regime_EL2 then HSCTLR.C else SCTLR.C;

    if ((acctype == AccType_IFETCH &&
        (walkstate.memattrs.memtype == MemType_Device || icache_en == '0')) ||
        (acctype != AccType_IFETCH &&
        walkstate.memattrs.memtype == MemType_Normal && dcache_en == '0')) then
        // Treat memory attributes as Normal Non-Cacheable
        memattrs = NormalNCMemAttr();
        memattrs.xs = walkstate.memattrs.xs;
    else

```

```

    memattrs = walkstate.memattrs;

if (regime == Regime\_EL10 && EL2Enabled\(\) &&
    (if ELUsingAArch32\(EL2\) then HCR.VM else HCR_EL2.VM) == '1') then
    // Shareability of target memory subject to stage 2 translation
    // is maintained as input to stage 2
    memattrs.shareability = walkstate.memattrs.shareability;
elsif (memattrs.memtype == MemType\_Device ||
    (memattrs.inner.attrs == MemAttr\_NC && memattrs.outer.attrs == MemAttr\_NC)) then
    // If the target memory is Device memory or is Normal memory
    // inner Non-Cacheable outer Non-Cacheable then it is forced to Outer Shareable
    memattrs.shareability = Shareability\_OSH;

// Output Address
oa = StageOA(walkstate.baseaddress, ZeroExtend(va), walkparams.tgx, walkstate.level);
ipa = CreateAddressDescriptor(ZeroExtend(va), oa, memattrs);

return (fault, ipa);

```





```

// AArch32.S1TranslateSD()
// =====
// Perform a stage 1 translation using short-descriptor format mapping VA to IPA/PA
// depending on the regime

(FaultRecord, AddressDescriptor, SDType) AArch32.S1TranslateSD(FaultRecord fault,
    Regime regime, bits(32) va, AccType acctype, boolean aligned, boolean iswrite)

    fault.secondstage = FALSE;
    fault.s2fslwalk = FALSE;

    if !AArch32.S1Enabled(regime) then
        (fault, ipa) = AArch32.S1DisabledOutput(fault, regime, va, acctype, aligned);
        return (fault, ipa, SDType UNKNOWN);

    (fault, walkstate) = AArch32.S1WalkSD(fault, regime, va);

    if fault.statuscode != Fault\_None then
        return (fault, AddressDescriptor UNKNOWN, SDType UNKNOWN);

    ispriv = AArch32.AccessUsesEL(acctype) != EL0;
    domain = AArch32.OutputDomain(walkstate.domain);
    SetInGuardedPage(FALSE); // AArch32-VMSEA does not guard any pages

    ntlsmd = if HaveTrapLoadStoreMultipleDeviceExt() then SCTLR.nTLSMD else '1';

    if AArch32.S1HasAlignmentFault(acctype, aligned, ntlsmd, walkstate.memattrs) then
        fault.statuscode = Fault\_Alignment;
    elseif !(acctype IN {AccType\_IC, AccType\_DC}) && domain == Domain\_NoAccess then
        fault.statuscode = Fault\_Domain;
    elseif domain == Domain\_Client then
        if IsAtomicRW(acctype) then
            if AArch32.S1SDHasPermissionsFault(walkstate.permissions,
                walkstate.memattrs.memtype,
                walkstate.baseaddress.paspace,
                ispriv, acctype, FALSE) then
                // The permission fault was not caused by lack of write permissions
                fault.statuscode = Fault\_Permission;
                fault.write = FALSE;
            elseif AArch32.S1SDHasPermissionsFault(walkstate.permissions,
                walkstate.memattrs.memtype,
                walkstate.baseaddress.paspace,
                ispriv, acctype, TRUE) then
                // The permission fault _was_ caused by lack of write permissions
                fault.statuscode = Fault\_Permission;
                fault.write = TRUE;
            elseif AArch32.S1SDHasPermissionsFault(walkstate.permissions,
                walkstate.memattrs.memtype,
                walkstate.baseaddress.paspace,
                ispriv, acctype, iswrite) then
                fault.statuscode = Fault\_Permission;

    if fault.statuscode != Fault\_None then
        fault.domain = walkstate.domain;
        return (fault, AddressDescriptor UNKNOWN, walkstate.sdftype);

    if ((acctype == AccType\_IFETCH &&
        (walkstate.memattrs.memtype == MemType\_Device || SCTLR.I == '0')) ||
        (acctype != AccType\_IFETCH &&
        walkstate.memattrs.memtype == MemType\_Normal && SCTLR.C == '0')) then
        // Treat memory attributes as Normal Non-Cacheable
        memattrs = NormalNCMemAttr();
        memattrs.xs = walkstate.memattrs.xs;
    else
        memattrs = walkstate.memattrs;

    if (regime == Regime\_EL10 && EL2Enabled() &&
        (if ELUsingAArch32(EL2) then HCR.VM else HCR_EL2.VM) == '1') then
        // Shareability of target memory subject to stage 2 translation
        // is maintained as input to stage 2

```

```

    memattrs.shareability = walkstate.memattrs.shareability;
elseif (memattrs.memtype == MemType\_Device ||
        (memattrs.inner.attrs == MemAttr\_NC && memattrs.outer.attrs == MemAttr\_NC)) then
    // If the target memory is Device memory or is Normal memory
    // inner Non-Cacheable outer Non-Cacheable then it is forced to Outer Shareable
    memattrs.shareability = Shareability\_OSH;

// Output Address
oa = AArch32.SDStage0A(walkstate.baseaddress, va, walkstate.sdftype);
ipa = CreateAddressDescriptor(ZeroExtend(va), oa, memattrs);

return (fault, ipa, walkstate.sdftype);

```



```

// AArch32.S2Translate()
// =====
// Perform a stage 2 translation mapping an IPA to a PA

(FaultRecord, AddressDescriptor) AArch32.S2Translate(FaultRecord fault,
    AddressDescriptor ipa, boolean s2fslwalk, AccType acctype,
    boolean aligned, boolean iswrite)

    assert IsZero(ipa.paddress.address<51:40>);

    if !ELUsingAArch32(EL2) then
        slaarch64 = FALSE;
        return AArch64.S2Translate(fault, ipa, slaarch64, s2fslwalk, acctype,
            aligned, iswrite);

    // Prepare fault fields in case a fault is detected
    fault.statuscode = Fault\_None;
    fault.secondstage = TRUE;
    fault.s2fslwalk = s2fslwalk;
    fault.ipaddress = ipa.paddress;

    walkparams = AArch32.GetS2TTWParams();

    if walkparams.vm == '0' then
        // Stage 2 is disabled
        return (fault, ipa);

    if AArch32.IPAIsOutOfRange(walkparams, ipa.paddress.address<39:0>) then
        fault.statuscode = Fault\_Translation;
        fault.level = 1;
        return (fault, AddressDescriptor UNKNOWN);

    (fault, walkstate) = AArch32.S2Walk(fault, walkparams, ipa);

    if fault.statuscode != Fault\_None then
        return (fault, AddressDescriptor UNKNOWN);

    ispriv = AArch32.AccessUsesEL(acctype) != EL0;

    if AArch32.S2HasAlignmentFault(acctype, aligned, walkstate.memattrs) then
        fault.statuscode = Fault\_Alignment;
    elseif IsAtomicRW(acctype) then
        assert !s2fslwalk; // AArch32 does not support HW update of TT
        if AArch32.S2HasPermissionsFault(s2fslwalk, walkparams,
            walkstate.permissions,
            walkstate.memattrs.memtype,
            ispriv, acctype, FALSE) then
            // The permission fault _was_ not caused by lack of write permissions
            fault.statuscode = Fault\_Permission;
            fault.write = FALSE;
        elseif AArch32.S2HasPermissionsFault(s2fslwalk, walkparams,
            walkstate.permissions,
            walkstate.memattrs.memtype,
            ispriv, acctype, TRUE) then
            // The permission fault _was_ caused by lack of write permissions
            fault.statuscode = Fault\_Permission;
            fault.write = TRUE;
    elseif AArch32.S2HasPermissionsFault(s2fslwalk, walkparams,
        walkstate.permissions,
        walkstate.memattrs.memtype,
        ispriv, acctype, iswrite) then
        fault.statuscode = Fault\_Permission;

    if ((s2fslwalk &&
        walkstate.memattrs.memtype == MemType\_Device) ||
        (acctype == AccType\_IFETCH &&
        (walkstate.memattrs.memtype == MemType\_Device || HCR2.ID == '1')) ||
        (acctype != AccType\_IFETCH &&
        walkstate.memattrs.memtype == MemType\_Normal && HCR2.CD == '1')) then
        // Treat memory attributes as Normal Non-Cacheable

```

```

    s2_memattrs = NormalNCMemAttr();
    s2_memattrs.xs = walkstate.memattrs.xs;
else
    s2_memattrs = walkstate.memattrs;

s2_memattrs = S2CombineS1MemAttrs(ipa.memattrs, s2_memattrs);

ipa_64 = ZeroExtend(ipa.paddress.address<39:0>, 64);
// Output Address
oa = Stage0A(walkstate.baseaddress, ipa_64, walkparams.tgx, walkstate.level);
pa = CreateAddressDescriptor(ipa.vaddress, oa, s2_memattrs);

return (fault, pa);

```

### Library pseudocode for aarch32/translation/translation/AArch32.SDStage0A

```

// AArch32.SDStage0A()
// =====
// Given the final walk state of a short-descriptor translation walk,
// map the untranslated input address bits to the base output address

FullAddress AArch32.SDStage0A(FullAddress baseaddress, bits(32) va, SDType sdftype)
    case sdftype of
        when SDType\_SmallPage      tsize = 12;
        when SDType\_LargePage     tsize = 16;
        when SDType\_Section       tsize = 20;
        when SDType\_Supersection  tsize = 24;

    // Output Address
    FullAddress oa;
    oa.address = baseaddress.address<51:tsize>:va<tsize-1:0>;
    oa.paspace = baseaddress.paspace;
    return oa;

```

### Library pseudocode for aarch32/translation/translation/AArch32.TranslateAddress

```

// AArch32.TranslateAddress()
// =====
// Main entry point for translating an address

AddressDescriptor AArch32.TranslateAddress(bits(32) va, AccType acctype,
                                           boolean iswrite, boolean aligned,
                                           integer size)

    regime = TranslationRegime(PSTATE.EL, acctype);
    if !RegimeUsingAArch32(regime) then
        return AArch64.TranslateAddress(ZeroExtend(va, 64), acctype, iswrite,
                                         aligned, size);
    result = AArch32.FullTranslate(va, acctype, iswrite, aligned);
    if !IsFault(result) then
        result.fault = AArch32.CheckDebug(va, acctype, iswrite, size);

    // Update virtual address for abort functions
    result.vaddress = ZeroExtend(va);

    return result;

```

## Library pseudocode for aarch32/translation/walk/AArch32.DecodeDescriptorTypeLD

```
// AArch32.DecodeDescriptorTypeLD()
// =====
// Determine whether the long-descriptor is a page, block or table

DescriptorType AArch32.DecodeDescriptorTypeLD(bits(64) descriptor, integer level)
    if descriptor<1:0> == '11' && level == FINAL_LEVEL then
        return DescriptorType_Page;
    elsif descriptor<1:0> == '11' then
        return DescriptorType_Table;
    elsif descriptor<1:0> == '01' && level != FINAL_LEVEL then
        return DescriptorType_Block;
    else
        return DescriptorType_Invalid;
```

## Library pseudocode for aarch32/translation/walk/AArch32.DecodeDescriptorTypeSD

```
// AArch32.DecodeDescriptorTypeSD()
// =====
// Determine the type of the short-descriptor

SDType AArch32.DecodeDescriptorTypeSD(bits(32) descriptor, integer level)
    if level == 1 && descriptor<1:0> == '01' then
        return SDType_Table;
    elsif level == 1 && descriptor<18,1> == '01' then
        return SDType_Section;
    elsif level == 1 && descriptor<18,1> == '11' then
        return SDType_Supersection;
    elsif level == 2 && descriptor<1:0> == '01' then
        return SDType_LargePage;
    elsif level == 2 && descriptor<1:0> == '1x' then
        return SDType_SmallPage;
    else
        return SDType_Invalid;
```

## Library pseudocode for aarch32/translation/walk/AArch32.S1IASize

```
// AArch32.S1IASize()
// =====
// Retrieve the number of bits containing the input address for stage 1 translation

integer AArch32.S1IASize(bits(3) txsz)
    return 32 - UInt(txsz);
```



```

// AArch32.S1WalkLD()
// =====
// Traverse stage 1 translation tables in long format to obtain the final descriptor

(FaultRecord, TTWState) AArch32.S1WalkLD(FaultRecord fault, Regime regime,
                                           S1TTPParams walkparams, bits(32) va)

    if regime == Regime\_EL2 then
        ttbr = HTTBR;
        txsz = walkparams.t0sz;
    else
        assert TTBCR.EAE == '1';
        varange = AArch32.GetVARange(va, walkparams.t0sz, walkparams.t1sz);
        if varange == VARange\_LOWER then
            ttbr = TTBR0;
            epd = TTBCR.EPD0;
            txsz = walkparams.t0sz;
        else
            ttbr = TTBR1;
            epd = TTBCR.EPD1;
            txsz = walkparams.t1sz;

    if regime != Regime\_EL2 && epd == '1' then
        fault.level = 1;
        fault.statuscode = Fault\_Translation;
        return (fault, TTWState UNKNOWN);

    // Input Address size
    iasize = AArch32.S1IASize(txsz);
    granulebits = TGxGranuleBits(walkparams.tgx);
    stride = granulebits - 3;
    startlevel = FINAL\_LEVEL - (((iasize-1) - granulebits) DIV stride);
    levels = FINAL\_LEVEL - startlevel;

    if !IsZero(ttbr<47:40>) then
        fault.statuscode = Fault\_AddressSize;
        fault.level = 0;
        return (fault, TTWState UNKNOWN);

    FullAddress baseaddress;
    baselsb = iasize - (levels*stride + granulebits) + 3;
    baseaddress.paspace = if IsSecure() then PAS_Secure else PAS_NonSecure;
    baseaddress.address = ZeroExtend(ttbr<39:baselsb>:Zeros(baselsb));

    TTWState walkstate;
    walkstate.baseaddress = baseaddress;
    walkstate.level = startlevel;
    walkstate.istable = TRUE;
    walkstate.memattrs = WalkMemAttrs(walkparams.sh, walkparams.irgn, walkparams.orgn);
    walkstate.permissions.ap_table = '00';
    walkstate.permissions.xn_table = '0';
    walkstate.permissions.pxn_table = '0';

    indexmsb = iasize - 1;
    bits(64) descriptor;
    AddressDescriptor walkaddress;
    repeat
        fault.level = walkstate.level;
        indexlsb = (FINAL\_LEVEL - walkstate.level)*stride + granulebits;
        bits(40) index = ZeroExtend(va<indexmsb:indexlsb>:'000');

        // VA is needed in the case of reporting an external abort
        walkaddress.vaddress = ZeroExtend(va);
        walkaddress.paddress.address = walkstate.baseaddress.address OR ZeroExtend(index);
        walkaddress.paddress.paspace = walkstate.baseaddress.paspace;

        disablecache = (if regime == Regime\_EL2 then HSCTLR.C else SCTLR.C) == '0';
        if disablecache then
            walkaddress.memattrs = NormalNCMemAttr();
            walkaddress.memattrs.xs = walkstate.memattrs.xs;
        else

```



```

walkaddress.memattrs = walkstate.memattrs;

// If the target memory for translation table walks is Normal memory
// inner Non-Cacheable outer Non-Cacheable then it is forced to Outer Shareable
// Note: this behaviour is overridden for addresses subject to stage 2.
if (walkaddress.memattrs.inner.attrs == MemAttr_NC &&
    walkaddress.memattrs.outer.attrs == MemAttr_NC) then
    walkaddress.memattrs.shareability = Shareability_OSH;

// If there are two stages of translation, then the first stage table walk addresses
// are themselves subject to translation
if regime == Regime_EL10 && EL2Enabled() then
    // Shareability of target memory subject to stage 2 translation
    // is maintained as input to stage 2.
    if (if ELUsingAArch32(EL2) then HCR.VM else HCR_EL2.VM) == '1' then
        walkaddress.memattrs.shareability = walkstate.memattrs.shareability;

s2fslwalk = TRUE;
s2acctype = AccType_TTW;
s2aligned = TRUE;
s2write = FALSE;
(s2fault, s2walkaddress) = AArch32.S2Translate(fault, walkaddress, s2fslwalk,
                                                s2acctype, s2aligned, s2write);

// Check for a fault on the stage 2 walk
if s2fault.statuscode != Fault_None then
    return (s2fault, TTWState UNKNOWN);

(fault, descriptor) = FetchDescriptor(walkparams.ee, s2walkaddress, fault);
else
    (fault, descriptor) = FetchDescriptor(walkparams.ee, walkaddress, fault);

if fault.statuscode != Fault_None then
    return (fault, TTWState UNKNOWN);

desctype = AArch32.DecodeDescriptorTypeID(descriptor, walkstate.level);

case desctype of
    when DescriptorType_Table
        if !IsZero(descriptor<47:40>) then
            fault.statuscode = Fault_AddressSize;
            return (fault, TTWState UNKNOWN);

        walkstate.baseaddress.address = ZeroExtend(descriptor<39:12>:Zeros(12));
        if walkstate.baseaddress.paspace == PAS_Secure && descriptor<63> == '1' then
            walkstate.baseaddress.paspace = PAS_NonSecure;

        if walkparams.hpd == '0' then
            walkstate.permissions.xn_table = (walkstate.permissions.xn_table OR
                                              descriptor<60>);
            walkstate.permissions.ap_table = (walkstate.permissions.ap_table OR
                                              descriptor<62:61>);
            walkstate.permissions.pxn_table = (walkstate.permissions.pxn_table OR
                                              descriptor<59>);

        walkstate.level = walkstate.level + 1;
        indexmsb = indexlsb - 1;

    when DescriptorType_Invalid
        fault.statuscode = Fault_Translation;
        return (fault, TTWState UNKNOWN);

    when DescriptorType_Page, DescriptorType_Block
        walkstate.istable = FALSE;

until desctype IN {DescriptorType_Page, DescriptorType_Block};

// Check the output address is inside the supported range
if !IsZero(descriptor<47:40>) then
    fault.statuscode = Fault_AddressSize;
    return (fault, TTWState UNKNOWN);

```

```

// Check the access flag
if descriptor<10> == '0' then
    fault.statuscode = Fault\_AccessFlag;
    return (fault, TTWState UNKNOWN);

walkstate.permissions.xn = descriptor<54>;
walkstate.permissions.pxn = descriptor<53>;
walkstate.permissions.ap = descriptor<7:6>:'1';
walkstate.contiguous = descriptor<52>;

walkstate.baseaddress.address = ZeroExtend(descriptor<39:indexlsb>:Zeros(indexlsb));
if walkstate.baseaddress.paspace == PAS_Secure && descriptor<5> == '1' then
    walkstate.baseaddress.paspace = PAS_NonSecure;

memattr = descriptor<4:2>;
sh = descriptor<9:8>;
attr = MAIRAttr(UInt(memattr), walkparams.mair);
slaarch64 = FALSE;
walkstate.memattrs = S1DecodeMemAttrs(attr, sh, slaarch64);

return (fault, walkstate);

```



```

// AArch32.S1WalkSD()
// =====
// Traverse stage 1 translation tables in short format to obtain the final descriptor

(FaultRecord, TTWState) AArch32.S1WalkSD(FaultRecord fault, Regime regime, bits(32) va)
    assert TTBCR.EAE == '0';

    // Determine correct Translation Table Base Register to use.
    n = UInt(TTBCR.N);
    if n == 0 || IsZero(va<31:(32-n)>) then
        ttb = TTBR0.TTB0:Zeros(7);
        pd = TTBCR.PD0;
        irgn = TTBR0.IRGN;
        rgn = TTBR0.RGN;
        s = TTBR0.S;
        nos = TTBR0.NOS;
    else
        n = 0; // TTBR1 translation always treats N as 0
        ttb = TTBR1.TTB1:Zeros(7);
        pd = TTBCR.PD1;
        irgn = TTBR1.IRGN;
        rgn = TTBR1.RGN;
        s = TTBR1.S;
        nos = TTBR1.NOS;

    // Check if Translation table walk disabled for translations with this Base register.
    if pd == '1' then
        fault.level = 1;
        fault.statuscode = Fault\_Translation;
        return (fault, TTWState UNKNOWN);

    FullAddress baseaddress;
    baseaddress.paspace = if IsSecure() then PAS_Secure else PAS_NonSecure;
    baseaddress.address = ZeroExtend(ttb<31:14-n>:Zeros(14-n));

    TTWState walkstate;
    walkstate.baseaddress = baseaddress;
    walkstate.memattrs = WalkMemAttrs(s:nos, irgn, rgn);
    walkstate.level = 1;
    walkstate.istable = TRUE;

    bits(4) domain;
    bits(32) descriptor;
    AddressDescriptor walkaddress;
    repeat
        fault.level = walkstate.level;

        bits(32) index;
        if walkstate.level == 1 then
            index = ZeroExtend(va<31-n:20>:'00');
        else
            index = ZeroExtend(va<19:12>:'00');

        walkaddress.vaddress = ZeroExtend(va);
        walkaddress.paddress.address = walkstate.baseaddress.address OR ZeroExtend(index);
        walkaddress.paddress.paspace = walkstate.baseaddress.paspace;

        if SCTLR.C == '0' then
            walkaddress.memattrs = NormalNCMemAttr();
            walkaddress.memattrs.xs = walkstate.memattrs.xs;
        else
            walkaddress.memattrs = walkstate.memattrs;

        // If the target memory for translation table walks is Normal memory
        // inner Non-Cacheable outer Non-Cacheable then it is forced to Outer Shareable
        // Note: this behaviour is overridden for addresses subject to stage 2.
        if (walkaddress.memattrs.inner.attrs == MemAttr\_NC &&
            walkaddress.memattrs.outer.attrs == MemAttr\_NC) then
            walkaddress.memattrs.shareability = Shareability\_OSH;

```

```

if regime == Regime\_EL10 && EL2Enabled() then
    // Shareability of target memory subject to stage 2 translation
    // is maintained as input to stage 2.
    if (if ELUsingAArch32(EL2) then HCR.VM else HCR_EL2.VM) == '1' then
        walkaddress.memattrs.shareability = walkstate.memattrs.shareability;

    s2fslwalk = TRUE;
    s2acctype = AccType\_TTW;
    s2aligned = TRUE;
    s2write = FALSE;
    (s2fault, s2walkaddress) = AArch32.S2Translate(fault, walkaddress, s2fslwalk,
                                                s2acctype, s2aligned, s2write);

    if s2fault.statuscode != Fault\_None then
        return (s2fault, TTWState UNKNOWN);

    (fault, descriptor) = FetchDescriptor(SCTLR.EE, s2walkaddress, fault);
else
    (fault, descriptor) = FetchDescriptor(SCTLR.EE, walkaddress, fault);

if fault.statuscode != Fault\_None then
    return (fault, TTWState UNKNOWN);

walkstate.sdftype = AArch32.DecodeDescriptorTypeSD(descriptor, walkstate.level);

case walkstate.sdftype of
    when SDType\_Invalid
        fault.domain = domain;
        fault.statuscode = Fault\_Translation;
        return (fault, TTWState UNKNOWN);

    when SDType\_Table
        domain = descriptor<8:5>;
        ns = descriptor<3>;
        pxn = descriptor<2>;

        walkstate.baseaddress.address = ZeroExtend(descriptor<31:10>:Zeros(10));
        walkstate.level = 2;

    when SDType\_SmallPage
        nG = descriptor<11>;
        s = descriptor<10>;
        ap = descriptor<9,5:4>;
        tex = descriptor<8:6>;
        c = descriptor<3>;
        b = descriptor<2>;
        xn = descriptor<0>;

        walkstate.baseaddress.address = ZeroExtend(descriptor<31:12>:Zeros(12));
        walkstate.istable = FALSE;

    when SDType\_LargePage
        xn = descriptor<15>;
        tex = descriptor<14:12>;
        nG = descriptor<11>;
        s = descriptor<10>;
        ap = descriptor<9,5:4>;
        c = descriptor<3>;
        b = descriptor<2>;

        walkstate.baseaddress.address = ZeroExtend(descriptor<31:16>:Zeros(16));
        walkstate.istable = FALSE;

    when SDType\_Section
        ns = descriptor<19>;
        nG = descriptor<17>;
        s = descriptor<16>;
        ap = descriptor<15,11:10>;
        tex = descriptor<14:12>;
        domain = descriptor<8:5>;

```

```

        xn      = descriptor<4>;
        c       = descriptor<3>;
        b       = descriptor<2>;
        pxn     = descriptor<0>;

        walkstate.baseaddress.address = ZeroExtend(descriptor<31:20>:Zeros(20));
        walkstate.istable = FALSE;

    when SDFType_Supersection
        ns      = descriptor<19>;
        nG      = descriptor<17>;
        s       = descriptor<16>;
        ap      = descriptor<15,11:10>;
        tex     = descriptor<14:12>;
        xn      = descriptor<4>;
        c       = descriptor<3>;
        b       = descriptor<2>;
        pxn     = descriptor<0>;
        domain  = '0000';

        walkstate.baseaddress.address = ZeroExtend(descriptor<8:5,23:20,31:24>:Zeros(24));
        walkstate.istable = FALSE;

until walkstate.sdftype != SDFType_Table;

if SCTL.R.AFE == '1' && ap<0> == '0' then
    fault.domain      = domain;
    fault.statuscode = Fault_AccessFlag;
    return (fault, TTWState UNKNOWN);

// Decode the TEX, C, B and S bits to produce target memory attributes
if SCTL.R.TRE == '1' then
    walkstate.memattrs = AArch32.RemappedTEXDecode(tex, c, b, s);
elsif RemapRegsHaveResetValues() then
    walkstate.memattrs = AArch32.DefaultTEXDecode(tex, c, b, s);
else
    walkstate.memattrs = MemoryAttributes IMPLEMENTATION_DEFINED;

walkstate.permissions.ap = ap;
walkstate.permissions.xn = xn;
walkstate.permissions.pxn = pxn;
walkstate.domain = domain;

if IsSecure() && ns == '0' then
    walkstate.baseaddress.paspace = PAS_Secure;
else
    walkstate.baseaddress.paspace = PAS_NonSecure;

return (fault, walkstate);

```

### Library pseudocode for aarch32/translation/walk/AArch32.S2IASize

```

// AArch32.S2IASize()
// =====
// Retrieve the number of bits containing the input address for stage 2 translation

integer AArch32.S2IASize(bits(4) t0sz)
    return 32 - SInt(t0sz);

```

### Library pseudocode for aarch32/translation/walk/AArch32.S2StartLevel

```

// AArch32.S2StartLevel()
// =====
// Determine the initial lookup level when performing a stage 2 translation
// table walk

integer AArch32.S2StartLevel(bits(2) sl0)
    return 2 - UInt(sl0);

```



```

// AArch32.S2Walk()
// =====
// Traverse stage 2 translation tables in long format to obtain the final descriptor

(FaultRecord, TTWState) AArch32.S2Walk(FaultRecord fault, S2TTWParams walkparams,
                                         AddressDescriptor ipa)

    if walkparams.sl0 == '1x' || AArch32.S2InconsistentSL(walkparams) then
        fault.statuscode = Fault_Translation;
        fault.level      = 1;
        return (fault, TTWState UNKNOWN);

    // Input Address size
    iasize      = AArch32.S2IASize(walkparams.t0sz);
    startlevel  = AArch32.S2StartLevel(walkparams.sl0);
    levels      = FINAL_LEVEL - startlevel;
    granulebits = TGxGranuleBits(walkparams.tgx);
    stride      = granulebits - 3;

    if !IsZero(VTTBR<47:40>) then
        fault.statuscode = Fault_AddressSize;
        fault.level      = 0;
        return (fault, TTWState UNKNOWN);

    FullAddress baseaddress;
    baselsb = iasize - (levels*stride + granulebits) + 3;
    baseaddress.paspace = PAS_NonSecure;
    baseaddress.address = ZeroExtend(VTTBR<39:baselsb>:Zeros(baselsb));

    TTWState walkstate;
    walkstate.baseaddress = baseaddress;
    walkstate.level       = startlevel;
    walkstate.istable     = TRUE;
    walkstate.memattrs    = WalkMemAttrs(walkparams.sh, walkparams.irgn,
                                         walkparams.orgn);

    indexmsb = iasize - 1;
    bits(64) descriptor;
    AddressDescriptor walkaddress;
    repeat
        fault.level = walkstate.level;

        indexlsb = (FINAL_LEVEL - walkstate.level)*stride + granulebits;
        bits(40) index = ZeroExtend(ipa.address.address<indexmsb:indexlsb>:'000');

        // Update virtual address for abort functions
        walkaddress.vaddress = ipa.vaddress;
        walkaddress.paddress.address = walkstate.baseaddress.address OR ZeroExtend(index);
        walkaddress.paddress.paspace = walkstate.baseaddress.paspace;
        if HCR2.CD == '1' then
            walkaddress.memattrs = NormalNCMemAttr();
            walkaddress.memattrs.xs = walkstate.memattrs.xs;
        else
            walkaddress.memattrs = walkstate.memattrs;

        // If the target memory for translation table walks is Normal memory
        // inner Non-Cacheable outer Non-Cacheable then it is forced to Outer Shareable
        if (walkaddress.memattrs.inner.attrs == MemAttr_NC &&
            walkaddress.memattrs.outer.attrs == MemAttr_NC) then
            walkaddress.memattrs.shareability = Shareability_OSH;

        (fault, descriptor) = FetchDescriptor(walkparams.tee, walkaddress, fault);

        if fault.statuscode != Fault_None then
            return (fault, TTWState UNKNOWN);

        descctype = AArch32.DecodeDescriptorTypeLD(descriptor, walkstate.level);

        case descctype of
            when DescriptorType_Table

```



```

        if !IsZero(descriptor<47:40>) then
            fault.statuscode = Fault_AddressSize;
            return (fault, TTWState UNKNOWN);

        walkstate.baseaddress.address = ZeroExtend(descriptor<39:12>:Zeros(12));
        walkstate.level = walkstate.level + 1;
        indexmsb = indexlsb - 1;

    when DescriptorType_Invalid
        fault.statuscode = Fault_Translation;
        return (fault, TTWState UNKNOWN);

    when DescriptorType_Page, DescriptorType_Block
        walkstate.istable = FALSE;

until desctype IN {DescriptorType_Page, DescriptorType_Block};

// Check the output address is inside the supported range
if !IsZero(descriptor<47:40>) then
    fault.statuscode = Fault_AddressSize;
    return (fault, TTWState UNKNOWN);

// Check the access flag
if descriptor<10> == '0' then
    fault.statuscode = Fault_AccessFlag;
    return (fault, TTWState UNKNOWN);

// Unpack the descriptor into address and upper and lower block attributes
walkstate.baseaddress.address = ZeroExtend(descriptor<39:indexlsb>:Zeros(indexlsb));

walkstate.permissions.s2ap = descriptor<7:6>;
walkstate.permissions.s2xn = descriptor<54>;
if HaveExtendedExecuteNeverExt() then
    walkstate.permissions.s2xnx = descriptor<53>;
else
    walkstate.permissions.s2xnx = '0';

memattr = descriptor<5:2>;
sh       = descriptor<9:8>;
walkstate.memattrs = S2DecodeMemAttrs(memattr, sh);
walkstate.contiguous = descriptor<52>;

return (fault, walkstate);

```

### Library pseudocode for aarch32/translation/walk/AArch32.TranslationSizeSD

```

// AArch32.TranslationSizeSD()
// =====
// Determine the size of the translation

integer AArch32.TranslationSizeSD(SDFTType sdftype)
    case sdftype of
        when SDFTType_SmallPage      tsize = 12;
        when SDFTType_LargePage      tsize = 16;
        when SDFTType_Section        tsize = 20;
        when SDFType_Supersection    tsize = 24;

    return tsize;

```

### Library pseudocode for aarch32/translation/walk/RemapRegsHaveResetValues

```

boolean RemapRegsHaveResetValues();

```

## Library pseudocode for aarch32/translation/walkparams/AArch32.GetS1TTWParams

```
// AArch32.GetS1TTWParams()
// =====
// Returns stage 1 translation table walk parameters from respective controlling
// system registers.

S1TTWParams AArch32.GetS1TTWParams(Regime regime, bits(32) va)
    S1TTWParams walkparams;

    case regime of
        when Regime_EL2 walkparams = AArch32.S1TTWParamsPL2();
        when Regime_EL10 walkparams = AArch32.S1TTWParamsPL10(va);
        when Regime_EL30 walkparams = AArch32.S1TTWParamsPL10(va);

    return walkparams;
```

## Library pseudocode for aarch32/translation/walkparams/AArch32.GetS2TTWParams

```
// AArch32.GetS2TTWParams()
// =====
// Gather walk parameters for stage 2 translation

S2TTWParams AArch32.GetS2TTWParams()
    S2TTWParams walkparams;

    walkparams.tgx = TGx_4KB;
    walkparams.s = VTCR.S;
    walkparams.t0sz = VTCR.T0SZ;
    walkparams.sl0 = VTCR.SL0;
    walkparams.irgn = VTCR.IRGN0;
    walkparams.orgn = VTCR.ORGNO;
    walkparams.sh = VTCR.SH0;
    walkparams.ee = HSCTLR.EE;
    walkparams.ptw = HCR.PTW;
    walkparams.vm = HCR.VM OR HCR.DC;

    // VTCR.S must match VTCR.T0SZ[3]
    if walkparams.s != walkparams.t0sz<3> then
        (-, walkparams.t0sz) = ConstrainUnpredictableBits(Unpredictable_RESVTCRS);

    return walkparams;
```

## Library pseudocode for aarch32/translation/walkparams/AArch32.GetVARange

```
// AArch32.GetVARange()
// =====
// Select the translation base address for stage 1 long-descriptor walks

VARange AArch32.GetVARange(bits(32) va, bits(3) t0sz, bits(3) t1sz)
    // Lower range Input Address size
    lo_iasize = AArch32.SLIASize(t0sz);
    // Upper range Input Address size
    up_iasize = AArch32.SLIASize(t1sz);

    if t1sz == '000' && t0sz == '000' then
        return VARange_LOWER;
    elsif t1sz == '000' then
        return if IsZero(va<31:lo_iasize>) then VARange_LOWER else VARange_UPPER;
    elsif t0sz == '000' then
        return if IsOnes(va<31:up_iasize>) then VARange_UPPER else VARange_LOWER;
    elsif IsZero(va<31:lo_iasize>) then
        return VARange_LOWER;
    elsif IsOnes(va<31:up_iasize>) then
        return VARange_UPPER;
    else
        // Will be reported as a Translation Fault
        return VARange UNKNOWN;
```

## Library pseudocode for aarch32/translation/walkparams/AArch32.S1TTWParamsEL2

```
// AArch32.S1TTWParamsEL2()
// =====
// Gather stage 1 translation table walk parameters for EL2 regime

S1TTWParams AArch32.S1TTWParamsPL2()
    S1TTWParams walkparams;

    walkparams.tgx = TGx_4KB;
    walkparams.t0sz = HTCR.T0SZ;
    walkparams.irgn = HTCR.SH0;
    walkparams.orgn = HTCR.IRGN0;
    walkparams.sh = HTCR.ORGNO;
    walkparams.hpd = if AArch32.HaveHPDExt() then HTCR.HPD else '0';
    walkparams.ee = HSCTLR.EE;
    walkparams.wxn = HSCTLR.WXN;
    if HaveTrapLoadStoreMultipleDeviceExt() then
        walkparams.ntlsmid = HSCTLR.nTLSMD;
    else
        walkparams.ntlsmid = '1';

    walkparams.mair = HMAIR1:HMAIR0;

    return walkparams;
```

## Library pseudocode for aarch32/translation/walkparams/AArch32.S1TTWParamsPL10

```
// AArch32.S1TTWParamsPL10()
// =====
// Gather stage 1 translation table walk parameters for EL3&0 regime as well as
// EL1&0 regime (with EL2 enabled or disabled)

S1TTWParams AArch32.S1TTWParamsPL10(bits(32) va)
    assert TTBCR.EAE == '1';
    S1TTWParams walkparams;

    walkparams.t0sz = TTBCR.T0SZ;
    walkparams.t1sz = TTBCR.T1SZ;
    walkparams.ee = SCTLR.EE;
    walkparams.wxn = SCTLR.WXN;
    walkparams.uwxn = SCTLR.UWXN;
    if HaveTrapLoadStoreMultipleDeviceExt() then
        walkparams.ntlsmid = SCTLR.nTLSMD;
    else
        walkparams.ntlsmid = '1';

    walkparams.mair = MAIR1:MAIR0;
    walkparams.sif = if ELUsingAArch32(EL3) then SCR.SIF else SCR_EL3.SIF;

    varange = AArch32.GetVARange(va, walkparams.t0sz, walkparams.t1sz);
    if varange == VARange_LOWER then
        walkparams.sh = TTBCR.SH0;
        walkparams.irgn = TTBCR.IRGN0;
        walkparams.orgn = TTBCR.ORGNO;
        if AArch32.HaveHPDExt() then
            walkparams.hpd = TTBCR.T2E AND TTBCR2.HPD0;
        else
            walkparams.hpd = '0';
    else
        walkparams.sh = TTBCR.SH1;
        walkparams.irgn = TTBCR.IRGN1;
        walkparams.orgn = TTBCR.ORGNO;
        if AArch32.HaveHPDExt() then
            walkparams.hpd = TTBCR.T2E AND TTBCR2.HPD1;
        else
            walkparams.hpd = '0';

    return walkparams;
```

## Library pseudocode for aarch64/debug/breakpoint/AArch64.BreakpointMatch

```
// AArch64.BreakpointMatch()
// =====
// Breakpoint matching in an AArch64 translation regime.

boolean AArch64.BreakpointMatch(integer n, bits(64) vaddress, AccType acctype, integer size)
    assert !ELUsingAArch32\(S1TranslationRegime\(\)\);
    assert n < GetNumBreakpoints\(\);

    enabled = DBGBCR_EL1[n].E == '1';
    ispriv = PSTATE.EL != EL0;
    linked = DBGBCR_EL1[n].BT == '0x01';
    isbreakpnt = TRUE;
    linked_to = FALSE;

    state_match = AArch64.StateMatch(DBGBCR_EL1[n].SSC, DBGBCR_EL1[n].HMC, DBGBCR_EL1[n].PMC,
                                     linked, DBGBCR_EL1[n].LBN, isbreakpnt, acctype, ispriv);
    value_match = AArch64.BreakpointValueMatch(n, vaddress, linked_to);

    if HaveAnyAArch32\(\) && size == 4 then // Check second halfword
        // If the breakpoint address and BAS of an Address breakpoint match the address of the
        // second halfword of an instruction, but not the address of the first halfword, it is
        // CONSTRAINED UNPREDICTABLE whether or not this breakpoint generates a Breakpoint debug
        // event.
        match_i = AArch64.BreakpointValueMatch(n, vaddress + 2, linked_to);
        if !value_match && match_i then
            value_match = ConstrainUnpredictableBool\(Unpredictable\_BPMATCHHALF\);
    if vaddress<1> == '1' && DBGBCR_EL1[n].BAS == '1111' then
        // The above notwithstanding, if DBGBCR_EL1[n].BAS == '1111', then it is CONSTRAINED
        // UNPREDICTABLE whether or not a Breakpoint debug event is generated for an instruction
        // at the address DBGBCR_EL1[n]+2.
        if value_match then value_match = ConstrainUnpredictableBool\(Unpredictable\_BPMATCHHALF\);

    match = value_match && state_match && enabled;

    return match;
```



```

// AArch64.BreakpointValueMatch()
// =====

boolean AArch64.BreakpointValueMatch(integer n, bits(64) vaddress, boolean linked_to)

// "n" is the identity of the breakpoint unit to match against.
// "vaddress" is the current instruction address, ignored if linked_to is TRUE and for Context
// matching breakpoints.
// "linked_to" is TRUE if this is a call from StateMatch for linking.

// If a non-existent breakpoint then it is CONSTRAINED UNPREDICTABLE whether this gives
// no match or the breakpoint is mapped to another UNKNOWN implemented breakpoint.
if n >= GetNumBreakpoints() then
    (c, n) = ConstrainUnpredictableInteger(0, GetNumBreakpoints() - 1, Unpredictable_BPNOTIMPL);
    assert c IN {Constraint_DISABLED, Constraint_UNKNOWN};
    if c == Constraint_DISABLED then return FALSE;

// If this breakpoint is not enabled, it cannot generate a match. (This could also happen on a
// call from StateMatch for linking).
if DBGBCR_EL1[n].E == '0' then return FALSE;

context_aware = (n >= (GetNumBreakpoints() - GetNumContextAwareBreakpoints()));

// If BT is set to a reserved type, behaves either as disabled or as a not-reserved type.
dbgtype = DBGBCR_EL1[n].BT;

if ((dbgtype IN {'011x', '11xx'}) && !HaveVirtHostExt() && !HaveV82Debug()) || // Context matching
    dbgtype == '010x' || // Reserved
    (dbgtype != '0x0x' && !context_aware) || // Context matching
    (dbgtype == '1xxx' && !HaveEL(EL2))) then // EL2 extension
    (c, dbgtype) = ConstrainUnpredictableBits(Unpredictable_RESBPTYPE);
    assert c IN {Constraint_DISABLED, Constraint_UNKNOWN};
    if c == Constraint_DISABLED then return FALSE;
    // Otherwise the value returned by ConstrainUnpredictableBits must be a not-reserved value

// Determine what to compare against.
match_addr = (dbgtype == '0x0x');
match_vmid = (dbgtype == '10xx');
match_cid = (dbgtype == '001x');
match_cid1 = (dbgtype IN {'101x', 'x11x'});
match_cid2 = (dbgtype == '11xx');
linked = (dbgtype == 'xxx1');

// If this is a call from StateMatch, return FALSE if the breakpoint is not programmed for a
// VMID and/or context ID match, or if not context-aware. The above assertions mean that the
// code can just test for match_addr == TRUE to confirm all these things.
if linked_to && (!linked || match_addr) then return FALSE;

// If called from BreakpointMatch return FALSE for Linked context ID and/or VMID matches.
if !linked_to && linked && !match_addr then return FALSE;

// Do the comparison.
if match_addr then
    byte = UInt(vaddress<1:0>);
    if HaveAnyAArch32() then
        // T32 instructions can be executed at EL0 in an AArch64 translation regime.
        assert byte IN {0,2}; // "vaddress" is halfword aligned
        byte_select_match = (DBGBCR_EL1[n].BAS<byte> == '1');
    else
        assert byte == 0; // "vaddress" is word aligned
        byte_select_match = TRUE; // DBGBCR_EL1[n].BAS<byte> is RES1
    // If the DBGxVR<n>_EL1.RESS field bits are not a sign extension of the MSB
    // of DBGxVR<n>_EL1.VA, it is UNPREDICTABLE whether they appear to be
    // included in the match.
    // If 'vaddress' is outside of the current virtual address space, then the access
    // generates a Translation fault.
    integer top = AArch64.VAMax();
    if !IsOnes(DBGxVR_EL1[n]<63:top>) && !IsZero(DBGxVR_EL1[n]<63:top>) then
        if ConstrainUnpredictableBool(Unpredictable_DBGxVR_RESS) then
            top = 63;

```

```

    BVR_match = (vaddress<top:2> == DBGGBVR_EL1[n]<top:2>) && byte_select_match;

elseif match_cid then
    if IsInHost() then
        BVR_match = (CONTEXTIDR_EL2<31:0> == DBGGBVR_EL1[n]<31:0>);
    else
        BVR_match = (PSTATE.EL IN {EL0, EL1} && CONTEXTIDR_EL1<31:0> == DBGGBVR_EL1[n]<31:0>);
elseif match_cid1 then
    BVR_match = (PSTATE.EL IN {EL0, EL1} && !IsInHost() && CONTEXTIDR_EL1<31:0> == DBGGBVR_EL1[n]<31:0>);
if match_vmid then
    if !Have16bitVMID() || VTCR_EL2.VS == '0' then
        vmid = ZeroExtend(VTTBR_EL2.VMID<7:0>, 16);
        bvr_vmid = ZeroExtend(DBGGBVR_EL1[n]<39:32>, 16);
    else
        vmid = VTTBR_EL2.VMID;
        bvr_vmid = DBGGBVR_EL1[n]<47:32>;
    BXVR_match = (PSTATE.EL IN {EL0, EL1} && EL2Enabled() &&
        !IsInHost() &&
        vmid == bvr_vmid);
elseif match_cid2 then
    BXVR_match = ((HaveVirtHostExt() || HaveV82Debug()) && EL2Enabled() &&
        DBGGBVR_EL1[n]<63:32> == CONTEXTIDR_EL2<31:0>);

bvr_match_valid = (match_addr || match_cid || match_cid1);
bxvr_match_valid = (match_vmid || match_cid2);

match = (!bxvr_match_valid || BXVR_match) && (!bvr_match_valid || BVR_match);

return match;

```

## Library pseudocode for aarch64/debug/breakpoint/AArch64.StateMatch

```
// AArch64.StateMatch()
// =====
// Determine whether a breakpoint or watchpoint is enabled in the current mode and state.

boolean AArch64.StateMatch(bits(2) SSC, bit HMC, bits(2) PxC, boolean linked, bits(4) LBN,
                           boolean isbreaknt, AccType acctype, boolean ispriv)
// "SSC", "HMC", "PxC" are the control fields from the DBGBCR[n] or DBGWCR[n] register.
// "linked" is TRUE if this is a linked breakpoint/watchpoint type.
// "LBN" is the linked breakpoint number from the DBGBCR[n] or DBGWCR[n] register.
// "isbreaknt" is TRUE for breakpoints, FALSE for watchpoints.
// "ispriv" is valid for watchpoints, and selects between privileged and unprivileged accesses.

// If parameters are set to a reserved type, behaves as either disabled or a defined type
(c, SSC, HMC, PxC) = CheckValidStateMatch(SSC, HMC, PxC, isbreaknt);
if c == Constraint\_DISABLED then return FALSE;
// Otherwise the HMC,SSC,PxC values are either valid or the values returned by
// CheckValidStateMatch are valid.

EL3_match = HaveEL(EL3) && HMC == '1' && SSC<0> == '0';
EL2_match = HaveEL(EL2) && ((HMC == '1' && (SSC:PxC != '1000')) || SSC == '11');
EL1_match = PxC<0> == '1';
EL0_match = PxC<1> == '1';

if HaveNV2Ext() && acctype == AccType\_NV2REGISTER && !isbreaknt then
    priv_match = EL2_match;
elsif !ispriv && !isbreaknt then
    priv_match = EL0_match;
else
    case PSTATE.EL of
        when EL3 priv_match = EL3_match;
        when EL2 priv_match = EL2_match;
        when EL1 priv_match = EL1_match;
        when EL0 priv_match = EL0_match;

case SSC of
    when '00' security_state_match = TRUE; // Both
    when '01' security_state_match = !IsSecure(); // Non-secure only
    when '10' security_state_match = IsSecure(); // Secure only
    when '11' security_state_match = (HMC == '1' || IsSecure()); // HMC=1 -> Both, 0 -> Secure only

if linked then
    // "LBN" must be an enabled context-aware breakpoint unit. If it is not context-aware then
    // it is CONSTRAINED UNPREDICTABLE whether this gives no match, or LBN is mapped to some
    // UNKNOWN breakpoint that is context-aware.
    lbn = UInt(LBN);
    first_ctx_cmp = GetNumBreakpoints() - GetNumContextAwareBreakpoints();
    last_ctx_cmp = GetNumBreakpoints() - 1;
    if (lbn < first_ctx_cmp || lbn > last_ctx_cmp) then
        (c, lbn) = ConstrainUnpredictableInteger(first_ctx_cmp, last_ctx_cmp, Unpredictable\_BPN0TCTX);
        assert c IN {Constraint\_DISABLED, Constraint\_NONE, Constraint\_UNKNOWN};
        case c of
            when Constraint\_DISABLED return FALSE; // Disabled
            when Constraint\_NONE linked = FALSE; // No linking
            // Otherwise ConstrainUnpredictableInteger returned a context-aware breakpoint

if linked then
    vaddress = bits(64) UNKNOWN;
    linked_to = TRUE;
    linked_match = AArch64.BreakpointValueMatch(lbn, vaddress, linked_to);

return priv_match && security_state_match && (!linked || linked_match);
```



## Library pseudocode for aarch64/debug/enables/AArch64.GenerateDebugExceptions

```
// AArch64.GenerateDebugExceptions()  
// =====  
  
boolean AArch64.GenerateDebugExceptions()  
    return AArch64.GenerateDebugExceptionsFrom(PSTATE.EL, IsSecure(), PSTATE.D);
```

## Library pseudocode for aarch64/debug/enables/AArch64.GenerateDebugExceptionsFrom

```
// AArch64.GenerateDebugExceptionsFrom()  
// =====  
  
boolean AArch64.GenerateDebugExceptionsFrom(bits(2) from, boolean secure, bit mask)  
  
    if OSLSR_EL1.OSLK == '1' || DoubleLockStatus() || Halted() then  
        return FALSE;  
  
    route_to_el2 = HaveEL(EL2) && (!secure || IsSecureEL2Enabled()) && (HCR_EL2.TGE == '1' || MDCR_EL2.TD  
    target = (if route_to_el2 then EL2 else EL1);  
    enabled = !HaveEL(EL3) || !secure || MDCR_EL3.SDD == '0';  
  
    if from == target then  
        enabled = enabled && MDCR_EL1.KDE == '1' && mask == '0';  
    else  
        enabled = enabled && UInt(target) > UInt(from);  
  
    return enabled;
```

## Library pseudocode for aarch64/debug/pmu/AArch64.CheckForPMUOverflow

```
// AArch64.CheckForPMUOverflow()  
// =====  
// Signal Performance Monitors overflow IRQ and CTI overflow events  
  
boolean AArch64.CheckForPMUOverflow()  
  
    pmuirq = PMCR_EL0.E == '1' && PMINTENSET_EL1<31> == '1' && PMOVSSET_EL0<31> == '1';  
    for n = 0 to GetNumEventCounters() - 1  
        if HaveEL(EL2) then  
            E = (if n < UInt(MDCR_EL2.HPMN) then PMCR_EL0.E else MDCR_EL2.HPME);  
        else  
            E = PMCR_EL0.E;  
        if E == '1' && PMINTENSET_EL1<n> == '1' && PMOVSSET_EL0<n> == '1' then pmuirq = TRUE;  
  
    SetInterruptRequestLevel(InterruptID\_PMUIRQ, if pmuirq then HIGH else LOW);  
  
    CTI_SetEventLevel(CrossTriggerIn\_PMUOverflow, if pmuirq then HIGH else LOW);  
  
    // The request remains set until the condition is cleared. (For example, an interrupt handler  
    // or cross-triggered event handler clears the overflow status flag by writing to PMOVSCLR_EL0.)  
  
    return pmuirq;
```



```

// AArch64.CountEvents()
// =====
// Return TRUE if counter "n" should count its event. For the cycle counter, n == 31.

boolean AArch64.CountEvents(integer n)
    assert n == 31 || n < GetNumEventCounters\(\);

    // Event counting is disabled in Debug state
    debug = Halted\(\);

    // In Non-secure state, some counters are reserved for EL2
    if HaveEL\(EL2\) then
        resvd_for_el2 = n >= UInt(MDCR_EL2.HPMN) && n != 31;
    else
        resvd_for_el2 = FALSE;

    // Main enable controls
    E = if resvd_for_el2 then MDCR_EL2.HPME else PMCR_EL0.E;
    enabled = E == '1' && PMCNTENSET_EL0<n> == '1';

    // Event counting is allowed unless it is prohibited by any rule below
    prohibited = FALSE;
    // Event counting in Secure state is prohibited if all of:
    // * EL3 is implemented
    // * MDCR_EL3.SPME == 0, and either:
    //   - FEAT_PMUv3p7 is not implemented
    //   - MDCR_EL3.MPMX == 0
    if HaveEL\(EL3\) && IsSecure\(\) then
        if HavePMUv3p7\(\) then
            prohibited = MDCR_EL3.<SPME,MPMX> == '00';
        else
            prohibited = MDCR_EL3.SPME == '0';

    // Event counting at EL3 is prohibited if all of:
    // * FEAT_PMUv3p7 is implemented
    // * One of the following is true:
    //   - MDCR_EL3.SPME == 1
    //   - PMNx is not reserved for EL2
    // * MDCR_EL3.MPMX == 1
    if !prohibited && PSTATE.EL == EL3 && HavePMUv3p7\(\) then
        prohibited = MDCR_EL3.MPMX == '1' && (MDCR_EL3.SPME == '1' || !resvd_for_el2);

    // Event counting at EL2 is prohibited if all of:
    // * The HPMD Extension is implemented
    // * PMNx is not reserved for EL2
    // * MDCR_EL2.HPMD == 1
    if !prohibited && PSTATE.EL == EL2 && HaveHPMDExt\(\) && !resvd_for_el2 then
        prohibited = MDCR_EL2.HPMD == '1';

    // The IMPLEMENTATION DEFINED authentication interface might override software
    if prohibited && !HaveNoSecurePMUDisableOverride\(\) then
        prohibited = !ExternalSecureNoninvasiveDebugEnabled\(\);

    // PMCR_EL0.DP disables the cycle counter when event counting is prohibited
    if enabled && prohibited && n == 31 then
        enabled = PMCR_EL0.DP == '0';

    // If FEAT_PMUv3p5 is implemented, cycle counting can be prohibited.
    // This is not overridden by PMCR_EL0.DP.
    if Havev85PMU\(\) && n == 31 then
        if HaveEL\(EL3\) && IsSecure\(\) && MDCR_EL3.SCCD == '1' then
            prohibited = TRUE;
        if PSTATE.EL == EL2 && MDCR_EL2.HCCD == '1' then
            prohibited = TRUE;

    // If FEAT_PMUv3p7 is implemented, cycle counting can be prohibited at EL3.
    // This is not overridden by PMCR_EL0.DP.
    if HavePMUv3p7\(\) && n == 31 then
        if PSTATE.EL == EL3 && MDCR_EL3.MCCD == '1' then
            prohibited = TRUE;

```

```

// Event counting might be frozen
frozen = FALSE;

// If FEAT_PMuV3p7 is implemented, event counting can be frozen
if HavePMUv3p7() && n != 31 then
    ovflw = PMOVSLR_EL0<GetNumEventCounters()-1:0>;
    if resvd_for_el2 then
        FZ = MDCR_EL2.HPMFZ0;
        ovflw<UInt(MDCR_EL2.HPMN)-1:0> = Zeros();
    else
        FZ = PMCR_EL0.FZ0;
        if HaveEL(EL2) then
            ovflw<GetNumEventCounters()-1:UInt(MDCR_EL2.HPMN)> = Zeros();
        frozen = FZ == '1' && !IsZero(ovflw);

// Event counting can be filtered by the {P, U, NSK, NSU, NSH, M, SH} bits
filter = if n == 31 then PMCCFILTR_EL0<31:0> else PMEVTYPER_EL0[n]<31:0>;

P = filter<31>;
U = filter<30>;
NSK = if HaveEL(EL3) then filter<29> else '0';
NSU = if HaveEL(EL3) then filter<28> else '0';
NSH = if HaveEL(EL2) then filter<27> else '0';
M = if HaveEL(EL3) then filter<26> else '0';
SH = if HaveEL(EL3) && HaveSecureEL2Ext() then filter<24> else '0';

case PSTATE.EL of
    when EL0 filtered = if IsSecure() then U == '1' else U != NSU;
    when EL1 filtered = if IsSecure() then P == '1' else P != NSK;
    when EL2 filtered = if IsSecure() then NSH == SH else NSH == '0';
    when EL3 filtered = M != P;

return !debug && enabled && !prohibited && !filtered && !frozen;

```

### Library pseudocode for aarch64/debug/statisticalprofiling/CheckProfilingBufferAccess

```

// CheckProfilingBufferAccess()
// =====

SysRegAccess CheckProfilingBufferAccess()
    if !HaveStatisticalProfiling() || PSTATE.EL == EL0 || UsingAArch32() then
        return SysRegAccess_UNDEFINED;

    if PSTATE.EL == EL1 && EL2Enabled() && MDCR_EL2.E2PB<0> != '1' then
        return SysRegAccess_TrapToEL2;

    if HaveEL(EL3) && PSTATE.EL != EL3 && MDCR_EL3.NSPB != SCR_EL3.NS:'1' then
        return SysRegAccess_TrapToEL3;

    return SysRegAccess_OK;

```

### Library pseudocode for aarch64/debug/statisticalprofiling/CheckStatisticalProfilingAccess

```

// CheckStatisticalProfilingAccess()
// =====

SysRegAccess CheckStatisticalProfilingAccess()
    if !HaveStatisticalProfiling() || PSTATE.EL == EL0 || UsingAArch32() then
        return SysRegAccess_UNDEFINED;

    if PSTATE.EL == EL1 && EL2Enabled() && MDCR_EL2.TPMS == '1' then
        return SysRegAccess_TrapToEL2;

    if HaveEL(EL3) && PSTATE.EL != EL3 && MDCR_EL3.NSPB != SCR_EL3.NS:'1' then
        return SysRegAccess_TrapToEL3;

    return SysRegAccess_OK;

```

### Library pseudocode for aarch64/debug/statisticalprofiling/CollectContextIDR1

```
// CollectContextIDR1()
// =====

boolean CollectContextIDR1()
    if !StatisticalProfilingEnabled() then return FALSE;
    if PSTATE.EL == EL2 then return FALSE;
    if EL2Enabled() && HCR_EL2.TGE == '1' then return FALSE;
    return PMSCR_EL1.CX == '1';
```

### Library pseudocode for aarch64/debug/statisticalprofiling/CollectContextIDR2

```
// CollectContextIDR2()
// =====

boolean CollectContextIDR2()
    if !StatisticalProfilingEnabled() then return FALSE;
    if !EL2Enabled() then return FALSE;
    return PMSCR_EL2.CX == '1';
```

### Library pseudocode for aarch64/debug/statisticalprofiling/CollectPhysicalAddress

```
// CollectPhysicalAddress()
// =====

boolean CollectPhysicalAddress()
    if !StatisticalProfilingEnabled() then return FALSE;
    (secure, el) = ProfilingBufferOwner();
    if ((!secure && HaveEL(EL2)) || IsSecureEL2Enabled()) then
        return PMSCR_EL2.PA == '1' && (el == EL2 || PMSCR_EL1.PA == '1');
    else
        return PMSCR_EL1.PA == '1';
```

## Library pseudocode for aarch64/debug/statisticalprofiling/CollectTimeStamp

```
// CollectTimeStamp()
// =====

TimeStamp CollectTimeStamp()

    if !StatisticalProfilingEnabled() then return TimeStamp_None;
    (-, el) = ProfilingBufferOwner();

    if el == EL2 then
        if PMSCR_EL2.TS == '0' then return TimeStamp_None;
    else
        if PMSCR_EL1.TS == '0' then return TimeStamp_None;

    if !HaveECVExt() then
        PCT_el1 = '0':PMSCR_EL1.PCT<0>;          // PCT<1> is RES0
    else
        PCT_el1 = PMSCR_EL1.PCT;
        if PCT_el1 == '10' then
            // Reserved value
            (-, PCT_el1) = ConstrainUnpredictableBits(Unpredictable_PMSCR_PCT);
    if EL2Enabled() then
        if !HaveECVExt() then
            PCT_el2 = '0':PMSCR_EL2.PCT<0>;      // PCT<1> is RES0
        else
            PCT_el2 = PMSCR_EL2.PCT;
            if PCT_el2 == '10' then
                // Reserved value
                (-, PCT_el2) = ConstrainUnpredictableBits(Unpredictable_PMSCR_PCT);
    case PCT_el2 of
        when '00'
            return TimeStamp_Virtual;
        when '01'
            if el == EL2 then return TimeStamp_Physical;
        when '11'
            assert HaveECVExt();                  // FEAT_ECV must be implemented
            if el == EL1 && PCT_el1 == '00' then
                return TimeStamp_Virtual;
            else
                return TimeStamp_OffsetPhysical;
        otherwise
            Unreachable();

    case PCT_el1 of
        when '00' return TimeStamp_Virtual;
        when '01' return TimeStamp_Physical;
        when '11'
            assert HaveECVExt();                  // FEAT_ECV must be implemented
            return TimeStamp_OffsetPhysical;
        otherwise Unreachable();
```

## Library pseudocode for aarch64/debug/statisticalprofiling/OpType

```
enumeration OpType {
    OpType_Load,          // Any memory-read operation other than atomics, compare-and-swap, and swap
    OpType_Store,         // Any memory-write operation, including atomics without return
    OpType_LoadAtomic,    // Atomics with return, compare-and-swap and swap
    OpType_Branch,        // Software write to the PC
    OpType_Other          // Any other class of operation
};
```

## Library pseudocode for aarch64/debug/statisticalprofiling/ProfilingBufferEnabled

```
// ProfilingBufferEnabled()
// =====

boolean ProfilingBufferEnabled()
    if !HaveStatisticalProfiling() then return FALSE;
    (secure, el) = ProfilingBufferOwner();
    non_secure_bit = if secure then '0' else '1';
    return (!ELUsingArch32(el) && non_secure_bit == SCR_EL3.NS &&
        PMBLIMITR_EL1.E == '1' && PMBSR_EL1.S == '0');
```

## Library pseudocode for aarch64/debug/statisticalprofiling/ProfilingBufferOwner

```
// ProfilingBufferOwner()
// =====

(boolean, bits(2)) ProfilingBufferOwner()
    secure = if HaveEL(EL3) then (MDCR_EL3.NSPB<1> == '0') else IsSecure();
    el = if HaveEL(EL2) && (!secure || IsSecureEL2Enabled()) && MDCR_EL2.E2PB == '00' then EL2 else EL1;
    return (secure, el);
```

## Library pseudocode for aarch64/debug/statisticalprofiling/ProfilingSynchronizationBarrier

```
// Barrier to ensure that all existing profiling data has been formatted, and profiling buffer
// addresses have been translated such that writes to the profiling buffer have been initiated.
// A following DSB completes when writes to the profiling buffer have completed.
ProfilingSynchronizationBarrier();
```

## Library pseudocode for aarch64/debug/statisticalprofiling/SPECollectRecord

```
// SPECollectRecord()
// =====
// Returns TRUE if the sampled class of instructions or operations, as
// determined by PMSFCR_EL1, are recorded and FALSE otherwise.

boolean SPECollectRecord(bits(64) events, integer total_latency, OpType optype)
    assert StatisticalProfilingEnabled();

    bits(64) mask = 0xAA<63:0>; // Bits [7,5,3,1]
    if HaveSVE() then mask<18:17> = Ones(); // Predicate flags
    if HaveStatisticalProfilingv1p1() then mask<11> = '1'; // Alignment Flag
    if HaveStatisticalProfilingv1p2() then mask<6> = '1'; // Not taken flag
    mask<63:48> = bits(16) IMPLEMENTATION_DEFINED;
    mask<31:24> = bits(8) IMPLEMENTATION_DEFINED;
    mask<15:12> = bits(4) IMPLEMENTATION_DEFINED;

    // Check for UNPREDICTABLE case
    if (HaveStatisticalProfilingv1p2() && PMSFCR_EL1.<FnE,FE> == '11' &&
        !IsZero(PMSEVFR_EL1 AND PMSNEVFR_EL1 AND mask)) then
        if ConstrainUnpredictableBool(Unpredictable_BADPMSFCR) then
            return FALSE;
    else
        // Filtering by event
        if PMSFCR_EL1.FE == '1' && !IsZero(PMSEVFR_EL1) then
            e = events AND mask;
            m = PMSEVFR_EL1 AND mask;
            if !IsZero(NOT(e) AND m) then return FALSE;

        // Filtering by inverse event
        if (HaveStatisticalProfilingv1p2() && PMSFCR_EL1.FnE == '1' &&
            !IsZero(PMSNEVFR_EL1)) then
            e = events AND mask;
            m = PMSNEVFR_EL1 AND mask;
            if !IsZero(e AND m) then return FALSE;

    // Filtering by type
    if PMSFCR_EL1.FT == '1' && !IsZero(PMSFCR_EL1.<B,LD,ST>) then
        case optype of
            when OpType_Branch
                if PMSFCR_EL1.B == '0' then return FALSE;
            when OpType_Load
                if PMSFCR_EL1.LD == '0' then return FALSE;
            when OpType_Store
                if PMSFCR_EL1.ST == '0' then return FALSE;
            when OpType_LoadAtomic
                if PMSFCR_EL1.<LD,ST> == '00' then return FALSE;
            otherwise
                return FALSE;

    // Filtering by latency
    if PMSFCR_EL1.FL == '1' && !IsZero(PMSLATFR_EL1.MINLAT) then
        if total_latency < UInt(PMSLATFR_EL1.MINLAT) then
            return FALSE;

    // Check for UNPREDICTABLE cases
    if ((PMSFCR_EL1.FE == '1' && IsZero(PMSEVFR_EL1 AND mask)) ||
        (PMSFCR_EL1.FT == '1' && IsZero(PMSFCR_EL1.<B,LD,ST>)) ||
        (PMSFCR_EL1.FL == '1' && IsZero(PMSLATFR_EL1.MINLAT))) then
        return ConstrainUnpredictableBool(Unpredictable_BADPMSFCR);

    if (HaveStatisticalProfilingv1p2() &&
        ((PMSFCR_EL1.FnE == '1' && IsZero(PMSNEVFR_EL1 AND mask)) ||
        (PMSFCR_EL1.<FnE,FE> == '11' &&
            !IsZero(PMSEVFR_EL1 AND PMSNEVFR_EL1 AND mask)))) then
        return ConstrainUnpredictableBool(Unpredictable_BADPMSFCR);

    return TRUE;
```



## Library pseudocode for aarch64/debug/statisticalprofiling/StatisticalProfilingEnabled

```
// StatisticalProfilingEnabled()
// =====

boolean StatisticalProfilingEnabled()
    if !HaveStatisticalProfiling() || UsingAArch32() || !ProfilingBufferEnabled() then
        return FALSE;

    in_host = EL2Enabled() && HCR_EL2.TGE == '1';
    (secure, el) = ProfilingBufferOwner();
    if UInt(el) < UInt(PSTATE.EL) || secure != IsSecure() || (in_host && el == EL1) then
        return FALSE;

    case PSTATE.EL of
        when EL3 Unreachable();
        when EL2 spe_bit = PMSCR_EL2.E2SPE;
        when EL1 spe_bit = PMSCR_EL1.E1SPE;
        when EL0 spe_bit = (if in_host then PMSCR_EL2.E0HSPE else PMSCR_EL1.E0SPE);

    return spe_bit == '1';
```

## Library pseudocode for aarch64/debug/statisticalprofiling/SysRegAccess

```
enumeration SysRegAccess { SysRegAccess_OK,
                           SysRegAccess_UNDEFINED,
                           SysRegAccess_TrapToEL1,
                           SysRegAccess_TrapToEL2,
                           SysRegAccess_TrapToEL3 };
```

## Library pseudocode for aarch64/debug/statisticalprofiling/TimeStamp

```
enumeration TimeStamp {
    TimeStamp_None,           // No timestamp
    TimeStamp_CoreSight,      // CoreSight time (IMPLEMENTATION DEFINED)
    TimeStamp_Physical,       // Physical counter value with no offset
    TimeStamp_OffsetPhysical, // Physical counter value minus CNTPOFF_EL2
    TimeStamp_Virtual };      // Physical counter value minus CNTVOFF_EL2
```

## Library pseudocode for aarch64/debug/takeexceptiondbg/AArch64.TakeExceptionInDebugState

```
// AArch64.TakeExceptionInDebugState()
// =====
// Take an exception in Debug state to an Exception level using AArch64.

AArch64.TakeExceptionInDebugState(bits(2) target_el, ExceptionRecord exception)
    assert HaveEL(target_el) && !ELUsingAArch32(target_el) && UInt(target_el) >= UInt(PSTATE.EL);

    if HaveIESB() then
        sync_errors = SCTRL[target_el].IESB == '1';
        if HaveDoubleFaultExt() then
            sync_errors = sync_errors || (SCR_EL3.<EA,NMEA> == '11' && target_el == EL3);
        // SCTRL[].IESB and/or SCR_EL3.NMEA (if applicable) might be ignored in Debug state.
        if !ConstrainUnpredictableBool(Unpredictable_IESBinDebug) then
            sync_errors = FALSE;
    else
        sync_errors = FALSE;

    SynchronizeContext();

    // If coming from AArch32 state, the top parts of the X[] registers might be set to zero
    from_32 = UsingAArch32();
    if from_32 then AArch64.MaybeZeroRegisterUppers();
    MaybeZeroSVEUppers(target_el);

    AArch64.ReportException(exception, target_el);

    PSTATE.EL = target_el;
    PSTATE.nRW = '0';
    PSTATE.SP = '1';

    SPSR[] = bits(64) UNKNOWN;
    ELR[] = bits(64) UNKNOWN;

    // PSTATE.{SS,D,A,I,F} are not observable and ignored in Debug state, so behave as if UNKNOWN.
    PSTATE.<SS,D,A,I,F> = bits(5) UNKNOWN;
    PSTATE.IL = '0';
    if from_32 then // Coming from AArch32
        PSTATE.IT = '00000000';
        PSTATE.T = '0'; // PSTATE.J is RES0
    if (HavePANExt() && (PSTATE.EL == EL1 || (PSTATE.EL == EL2 && ELIsInHost(EL0))) &&
        SCTRL[].SPAN == '0') then
        PSTATE.PAN = '1';
    if HaveUA0Ext() then PSTATE.UA0 = '0';
    if HaveBTIExt() then PSTATE.BTYPE = '00';
    if HaveSSBSExt() then PSTATE.SSBS = bit UNKNOWN;
    if HaveMTEEExt() then PSTATE.TCO = '1';

    DLR_EL0 = bits(64) UNKNOWN;
    DSPSR_EL0 = bits(64) UNKNOWN;

    EDSCR.ERR = '1';
    UpdateEDSCRFields(); // Update EDSCR processor state flags.

    if sync_errors then
        SynchronizeErrors();

    EndOfInstruction();
```

## Library pseudocode for aarch64/debug/watchpoint/AArch64.WatchpointByteMatch

```
// AArch64.WatchpointByteMatch()
// =====

boolean AArch64.WatchpointByteMatch(integer n, AccType acctype, bits(64) vaddress)

integer top = AArch64.VAMax();
bottom = if DBGWVR_EL1[n]<2> == '1' then 2 else 3;           // Word or doubleword
byte_select_match = (DBGWCR_EL1[n].BAS<UInt(vaddress<bottom-1:0>)> != '0');
mask = UInt(DBGWCR_EL1[n].MASK);

// If DBGWCR_EL1[n].MASK is non-zero value and DBGWCR_EL1[n].BAS is not set to '11111111', or
// DBGWCR_EL1[n].BAS specifies a non-contiguous set of bytes behavior is CONSTRAINED
// UNPREDICTABLE.
if mask > 0 && !IsOnes(DBGWCR_EL1[n].BAS) then
    byte_select_match = ConstrainUnpredictableBool(Unpredictable\_WPMASKANDBAS);
else
    LSB = (DBGWCR_EL1[n].BAS AND NOT(DBGWCR_EL1[n].BAS - 1)); MSB = (DBGWCR_EL1[n].BAS + LSB);
    if !IsZero(MSB AND (MSB - 1)) then                        // Not contiguous
        byte_select_match = ConstrainUnpredictableBool(Unpredictable\_WPBASCONTIGUOUS);
        bottom = 3;                                          // For the whole doubleword

// If the address mask is set to a reserved value, the behavior is CONSTRAINED UNPREDICTABLE.
if mask > 0 && mask <= 2 then
    (c, mask) = ConstrainUnpredictableInteger(3, 31, Unpredictable\_RESWPMASK);
    assert c IN {Constraint\_DISABLED, Constraint\_NONE, Constraint\_UNKNOWN};
    case c of
        when Constraint\_DISABLED return FALSE;           // Disabled
        when Constraint\_NONE mask = 0;                   // No masking
        // Otherwise the value returned by ConstrainUnpredictableInteger is a not-reserved value

if mask > bottom then
    // If the DBGxVR<n>_EL1.RESS field bits are not a sign extension of the MSB
    // of DBGBVR<n>_EL1.VA, it is UNPREDICTABLE whether they appear to be
    // included in the match.
    if !IsOnes(DBGBVR_EL1[n]<63:top>) && !IsZero(DBGBVR_EL1[n]<63:top>) then
        if ConstrainUnpredictableBool(Unpredictable\_DBGxVR\_RESS) then
            top = 63;
        WVR_match = (vaddress<top:mask> == DBGWVR_EL1[n]<top:mask>);
        // If masked bits of DBGWVR_EL1[n] are not zero, the behavior is CONSTRAINED UNPREDICTABLE.
        if WVR_match && !IsZero(DBGWVR_EL1[n]<mask-1:bottom>) then
            WVR_match = ConstrainUnpredictableBool(Unpredictable\_WPMASKEDBITS);
else
    WVR_match = vaddress<top:bottom> == DBGWVR_EL1[n]<top:bottom>;

return WVR_match && byte_select_match;
```

## Library pseudocode for aarch64/debug/watchpoint/AArch64.WatchpointMatch

```
// AArch64.WatchpointMatch()
// =====
// Watchpoint matching in an AArch64 translation regime.

boolean AArch64.WatchpointMatch(integer n, bits(64) vaddress, integer size, boolean ispriv,
                                AccType acctype, boolean iswrite)
    assert !ELUsingAArch32(S1TranslationRegime());
    assert n < GetNumWatchpoints();

    // "ispriv" is:
    // * FALSE for all loads, stores, and atomic operations executed at EL0.
    // * FALSE if the access is unprivileged.
    // * TRUE for all other loads, stores, and atomic operations.

    enabled = DBGWCR_EL1[n].E == '1';
    linked = DBGWCR_EL1[n].WT == '1';
    isbreakpnt = FALSE;

    state_match = AArch64.StateMatch(DBGWCR_EL1[n].SSC, DBGWCR_EL1[n].HMC, DBGWCR_EL1[n].PAC,
                                     linked, DBGWCR_EL1[n].LBN, isbreakpnt, acctype, ispriv);
    ls_match = FALSE;
    if acctype == AccType_ATOMICRW then
        ls_match = (DBGWCR_EL1[n].LSC != '00');
    else
        ls_match = (DBGWCR_EL1[n].LSC<(if iswrite then 1 else 0)> == '1');

    value_match = FALSE;
    for byte = 0 to size - 1
        value_match = value_match || AArch64.WatchpointByteMatch(n, acctype, vaddress + byte);

    return value_match && state_match && ls_match && enabled;
```

## Library pseudocode for aarch64/exceptions/aborts/AArch64.Abort

```
// AArch64.Abort()
// =====
// Abort and Debug exception handling in an AArch64 translation regime.

AArch64.Abort(bits(64) vaddress, FaultRecord fault)

    if IsDebugException(fault) then
        if fault.acctype == AccType_IFETCH then
            if UsingAArch32() && fault.debugmoe == DebugException_VectorCatch then
                AArch64.VectorCatchException(fault);
            else
                AArch64.BreakpointException(fault);
        else
            AArch64.WatchpointException(vaddress, fault);
    elsif fault.acctype == AccType_IFETCH then
        AArch64.InstructionAbort(vaddress, fault);
    else
        AArch64.DataAbort(vaddress, fault);
```

## Library pseudocode for aarch64/exceptions/aborts/AArch64.AbortSyndrome

```
// AArch64.AbortSyndrome()
// =====
// Creates an exception syndrome record for Abort and Watchpoint exceptions
// from an AArch64 translation regime.

ExceptionRecord AArch64.AbortSyndrome(Exception exceptype, FaultRecord fault, bits(64) vaddress)
    exception = ExceptionSyndrome(exceptype);

    d_side = exceptype IN {Exception_DataAbort, Exception_NV2DataAbort, Exception_Watchpoint, Exception_MVADataAbort}

    (exception.syndrome, exception.syndrome2) = AArch64.FaultSyndrome(d_side, fault);
    exception.vaddress = ZeroExtend(vaddress);
    if IPAValid(fault) then
        exception.ipavalid = TRUE;
        exception.NS = if fault.ipaddress.paspace == PAS_NonSecure then '1' else '0';
        exception.ipaddress = fault.ipaddress.address;
    else
        exception.ipavalid = FALSE;

    return exception;
```

## Library pseudocode for aarch64/exceptions/aborts/AArch64.CheckPCAlignment

```
// AArch64.CheckPCAlignment()
// =====

AArch64.CheckPCAlignment()

    bits(64) pc = ThisInstrAddr();
    if pc<1:0> != '00' then
        AArch64.PCAlignmentFault();
```

## Library pseudocode for aarch64/exceptions/aborts/AArch64.DataAbort

```
// AArch64.DataAbort()
// =====

AArch64.DataAbort(bits(64) vaddress, FaultRecord fault)
    route_to_el3 = HaveEL(EL3) && SCR_EL3.EA == '1' && IsExternalAbort(fault);
    route_to_el2 = (PSTATE.EL IN {EL0, EL1} && EL2Enabled() && (HCR_EL2.TGE == '1' ||
        (HaveRASExt() && HCR_EL2.TEA == '1' && IsExternalAbort(fault)) ||
        (HaveNV2Ext() && fault.acctype == AccType_NV2REGISTER) ||
        IsSecondStage(fault)));

    bits(64) preferred_exception_return = ThisInstrAddr();
    if (HaveDoubleFaultExt() && (PSTATE.EL == EL3 || route_to_el3) &&
        IsExternalAbort(fault) && SCR_EL3.EASE == '1') then
        vect_offset = 0x180;
    else
        vect_offset = 0x0;
    if HaveNV2Ext() && fault.acctype == AccType_NV2REGISTER then
        exception = AArch64.AbortSyndrome(Exception_NV2DataAbort, fault, vaddress);
    else
        exception = AArch64.AbortSyndrome(Exception_DataAbort, fault, vaddress);
    if PSTATE.EL == EL3 || route_to_el3 then
        AArch64.TakeException(EL3, exception, preferred_exception_return, vect_offset);
    elsif PSTATE.EL == EL2 || route_to_el2 then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/aborts/AArch64.EffectiveTCF

```
// AArch64.EffectiveTCF()
// =====
// Returns the TCF field applied to tag check faults in the given Exception level.

bits(2) AArch64.EffectiveTCF(AccType acctype)
    bits(2) tcf, el;
    el = S1TranslationRegime();

    if el == EL3 then
        tcf = SCTLR_EL3.TCF;
    elsif el == EL2 then
        if AArch64.AccessUsesEL(acctype) == EL0 then
            tcf = SCTLR_EL2.TCF0;
        else
            tcf = SCTLR_EL2.TCF;
    elsif el == EL1 then
        if AArch64.AccessUsesEL(acctype) == EL0 then
            tcf = SCTLR_EL1.TCF0;
        else
            tcf = SCTLR_EL1.TCF;

    if tcf == '11' then //reserved value
        if !HaveMTE3Ext() then
            (-,tcf) = ConstrainUnpredictableBits(Unpredictable\_RESTCF);

    return tcf;
```

## Library pseudocode for aarch64/exceptions/aborts/AArch64.InstructionAbort

```
// AArch64.InstructionAbort()
// =====

AArch64.InstructionAbort(bits(64) vaddress, FaultRecord fault)
    // External aborts on instruction fetch must be taken synchronously
    if HaveDoubleFaultExt() then assert fault.statuscode != Fault\_AsyncExternal;
    route_to_el3 = HaveEL(EL3) && SCR_EL3.EA == '1' && IsExternalAbort(fault);
    route_to_el2 = (PSTATE.EL IN {EL0, EL1} && EL2Enabled() &&
        (HCR_EL2.TGE == '1' ||
        (HaveRASExt() && HCR_EL2.TEA == '1' && IsExternalAbort(fault)) ||
        IsSecondStage(fault)));

    bits(64) preferred_exception_return = ThisInstrAddr();

    if (HaveDoubleFaultExt() && (PSTATE.EL == EL3 || route_to_el3) &&
        IsExternalAbort(fault) && SCR_EL3.EASE == '1') then
        vect_offset = 0x180;
    else
        vect_offset = 0x0;

    exception = AArch64.AbortSyndrome(Exception\_InstructionAbort, fault, vaddress);

    if PSTATE.EL == EL3 || route_to_el3 then
        AArch64.TakeException(EL3, exception, preferred_exception_return, vect_offset);
    elsif PSTATE.EL == EL2 || route_to_el2 then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/aborts/AArch64.PCAlignmentFault

```
// AArch64.PCAlignmentFault()
// =====
// Called on unaligned program counter in AArch64 state.

AArch64.PCAlignmentFault()

    bits(64) preferred_exception_return = ThisInstrAddr\(\);
    vect_offset = 0x0;

    exception = ExceptionSyndrome\(Exception\_PCAlignment\);
    exception.vaddress = ThisInstrAddr\(\);

    if UInt(PSTATE.EL) > UInt(EL1) then
        AArch64.TakeException(PSTATE.EL, exception, preferred_exception_return, vect_offset);
    elsif EL2Enabled() && HCR_EL2.TGE == '1' then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/aborts/AArch64.RaiseTagCheckFault

```
// AArch64.RaiseTagCheckFault()
// =====
// Raise a tag check fault exception.

AArch64.RaiseTagCheckFault(bits(64) va, boolean write)
    bits(2) target_el;
    bits(64) preferred_exception_return = ThisInstrAddr\(\);
    integer vect_offset = 0x0;

    if PSTATE.EL == EL0 then
        target_el = if HCR_EL2.TGE == '0' then EL1 else EL2;
    else
        target_el = PSTATE.EL;

    exception = ExceptionSyndrome\(Exception\_DataAbort\);
    exception.syndrome<5:0> = '010001';
    if write then
        exception.syndrome<6> = '1';
    exception.vaddress = bits(4) UNKNOWN : va<59:0>;

    AArch64.TakeException(target_el, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/aborts/AArch64.ReportTagCheckFault

```
// AArch64.ReportTagCheckFault()
// =====
// Records a tag check fault exception into the appropriate TCFR_ELx.

AArch64.ReportTagCheckFault(bits(2) el, bit ttbr)
    if el == EL3 then
        assert ttbr == '0';
        TFSR_EL3.TF0 = '1';
    elseif el == EL2 then
        if ttbr == '0' then
            TFSR_EL2.TF0 = '1';
        else
            TFSR_EL2.TF1 = '1';
    elseif el == EL1 then
        if ttbr == '0' then
            TFSR_EL1.TF0 = '1';
        else
            TFSR_EL1.TF1 = '1';
    elseif el == EL0 then
        if ttbr == '0' then
            TFSRE0_EL1.TF0 = '1';
        else
            TFSRE0_EL1.TF1 = '1';
```

## Library pseudocode for aarch64/exceptions/aborts/AArch64.SPAlignmentFault

```
// AArch64.SPAlignmentFault()
// =====
// Called on an unaligned stack pointer in AArch64 state.

AArch64.SPAlignmentFault()

    bits(64) preferred_exception_return = ThisInstrAddr\(\);
    vect_offset = 0x0;

    exception = ExceptionSyndrome\(Exception\_SPAlignment\);

    if UInt(PSTATE.EL) > UInt(EL1) then
        AArch64.TakeException(PSTATE.EL, exception, preferred_exception_return, vect_offset);
    elseif EL2Enabled() && HCR_EL2.TGE == '1' then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```



## Library pseudocode for aarch64/exceptions/aborts/AArch64.TagCheckFault

```
// AArch64.TagCheckFault()
// =====
// Handle a tag check fault condition.

AArch64.TagCheckFault(bits(64) vaddress, AccType acctype, boolean iswrite)
    bits(2) tcf = AArch64.EffectiveTCF(acctype);

    case tcf of
        when '00'          // Tag Check Faults have no effect on the PE
            return;
        when '01'          // Tag Check Faults cause a synchronous exception
            AArch64.RaiseTagCheckFault(vaddress, iswrite);
        when '10'          // Tag Check Faults are asynchronously accumulated
            AArch64.ReportTagCheckFault(PSTATE.EL, vaddress<55>);
        when '11'          // Tag Check Faults cause a synchronous exception on reads or on
                        // a read-write access, and are asynchronously accumulated on writes
            // Check for access performing both a read and a write.
            readwrite = acctype IN {AccType\_ATOMICRW,
                                   AccType\_ORDEREDATOMICRW,
                                   AccType\_ORDEREDRW};

            if !iswrite || readwrite then
                AArch64.RaiseTagCheckFault(vaddress, iswrite);
            else
                AArch64.ReportTagCheckFault(PSTATE.EL, vaddress<55>);
```

## Library pseudocode for aarch64/exceptions/aborts/BranchTargetException

```
// BranchTargetException()
// =====
// Raise branch target exception.

AArch64.BranchTargetException(bits(52) vaddress)

    route_to_el2 = PSTATE.EL == EL0 && EL2Enabled() && HCR_EL2.TGE == '1';
    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x0;

    exception = ExceptionSyndrome(Exception\_BranchTarget);
    exception.syndrome<1:0> = PSTATE.BTYPE;
    exception.syndrome<24:2> = Zeros();          // RES0

    if UInt(PSTATE.EL) > UInt(EL1) then
        AArch64.TakeException(PSTATE.EL, exception, preferred_exception_return, vect_offset);
    elsif route_to_el2 then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/async/AArch64.TakePhysicalFIQException

```
// AArch64.TakePhysicalFIQException()
// =====

AArch64.TakePhysicalFIQException()

    route_to_el3 = HaveEL(EL3) && SCR_EL3.FIQ == '1';
    route_to_el2 = (PSTATE.EL IN {EL0, EL1} && EL2Enabled() &&
                    (HCR_EL2.TGE == '1' || HCR_EL2.FMO == '1'));
    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x100;
    exception = ExceptionSyndrome(Exception_FIQ);

    if route_to_el3 then
        AArch64.TakeException(EL3, exception, preferred_exception_return, vect_offset);
    elsif PSTATE.EL == EL2 || route_to_el2 then
        assert PSTATE.EL != EL3;
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        assert PSTATE.EL IN {EL0, EL1};
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/async/AArch64.TakePhysicalIRQException

```
// AArch64.TakePhysicalIRQException()
// =====
// Take an enabled physical IRQ exception.

AArch64.TakePhysicalIRQException()

    route_to_el3 = HaveEL(EL3) && SCR_EL3.IRQ == '1';
    route_to_el2 = (PSTATE.EL IN {EL0, EL1} && EL2Enabled() &&
                    (HCR_EL2.TGE == '1' || HCR_EL2.IMO == '1'));
    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x80;

    exception = ExceptionSyndrome(Exception_IRQ);

    if route_to_el3 then
        AArch64.TakeException(EL3, exception, preferred_exception_return, vect_offset);
    elsif PSTATE.EL == EL2 || route_to_el2 then
        assert PSTATE.EL != EL3;
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        assert PSTATE.EL IN {EL0, EL1};
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/async/AArch64.TakePhysicalSErrorException

```
// AArch64.TakePhysicalSErrorException()
// =====

AArch64.TakePhysicalSErrorException(bits(25) syndrome)

    route_to_el3 = HaveEL(EL3) && SCR_EL3.EA == '1';
    route_to_el2 = (PSTATE.EL IN {EL0, EL1} && EL2Enabled() &&
                    (HCR_EL2.TGE == '1' || (!IsInHost() && HCR_EL2.AMO == '1')));
    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x180;

    bits(2) target_el;
    if PSTATE.EL == EL3 || route_to_el3 then
        target_el = EL3;
    elsif PSTATE.EL == EL2 || route_to_el2 then
        target_el = EL2;
    else
        target_el = EL1;

    if IsSErrorEdgeTriggered(target_el, syndrome) then
        ClearPendingPhysicalSError();

    exception = ExceptionSyndrome(Exception_SError);
    exception.syndrome = syndrome;
    AArch64.TakeException(target_el, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/async/AArch64.TakeVirtualFIQException

```
// AArch64.TakeVirtualFIQException()
// =====

AArch64.TakeVirtualFIQException()
    assert PSTATE.EL IN {EL0, EL1} && EL2Enabled();
    assert HCR_EL2.TGE == '0' && HCR_EL2.FM0 == '1'; // Virtual IRQ enabled if TGE==0 and FM0==1

    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x100;

    exception = ExceptionSyndrome(Exception_FIQ);

    AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/async/AArch64.TakeVirtualIRQException

```
// AArch64.TakeVirtualIRQException()
// =====

AArch64.TakeVirtualIRQException()
    assert PSTATE.EL IN {EL0, EL1} && EL2Enabled();
    assert HCR_EL2.TGE == '0' && HCR_EL2.IM0 == '1'; // Virtual IRQ enabled if TGE==0 and IM0==1

    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x80;

    exception = ExceptionSyndrome(Exception_IRQ);

    AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/async/AArch64.TakeVirtualSErrorException

```
// AArch64.TakeVirtualSErrorException()
// =====

AArch64.TakeVirtualSErrorException(bits(25) syndrome)

    assert PSTATE.EL IN {EL0, EL1} && EL2Enabled();
    assert HCR_EL2.TGE == '0' && HCR_EL2.AMO == '1'; // Virtual SError enabled if TGE==0 and AMO==1

    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x180;
    exception = ExceptionSyndrome(Exception_SError);

    if HaveRASExt() then
        exception.syndrome<24> = VESR_EL2.IDS;
        exception.syndrome<23:0> = VESR_EL2.ISS;
    else
        impdef_syndrome = syndrome<24> == '1';
        if impdef_syndrome then exception.syndrome = syndrome;

    ClearPendingVirtualSError();
    AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/debug/AArch64.BreakpointException

```
// AArch64.BreakpointException()
// =====

AArch64.BreakpointException(FaultRecord fault)
    assert PSTATE.EL != EL3;

    route_to_el2 = (PSTATE.EL IN {EL0, EL1} && EL2Enabled() &&
        (HCR_EL2.TGE == '1' || MDCR_EL2.TDE == '1'));

    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x0;

    vaddress = bits(64) UNKNOWN;
    exception = AArch64.AbortSyndrome(Exception_Breakpoint, fault, vaddress);

    if PSTATE.EL == EL2 || route_to_el2 then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/debug/AArch64.SoftwareBreakpoint

```
// AArch64.SoftwareBreakpoint()
// =====

AArch64.SoftwareBreakpoint(bits(16) immediate)

    route_to_el2 = (PSTATE.EL IN {EL0, EL1} &&
        EL2Enabled() && (HCR_EL2.TGE == '1' || MDCR_EL2.TDE == '1'));

    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x0;

    exception = ExceptionSyndrome(Exception_SoftwareBreakpoint);
    exception.syndrome<15:0> = immediate;

    if UInt(PSTATE.EL) > UInt(EL1) then
        AArch64.TakeException(PSTATE.EL, exception, preferred_exception_return, vect_offset);
    elseif route_to_el2 then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/debug/AArch64.SoftwareStepException

```
// AArch64.SoftwareStepException()
// =====

AArch64.SoftwareStepException()
    assert PSTATE.EL != EL3;

    route_to_el2 = (PSTATE.EL IN {EL0, EL1} && EL2Enabled() &&
                    (HCR_EL2.TGE == '1' || MDCR_EL2.TDE == '1'));

    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x0;

    exception = ExceptionSyndrome(Exception_SoftwareStep);
    if SoftwareStep_DidNotStep() then
        exception.syndrome<24> = '0';
    else
        exception.syndrome<24> = '1';
        exception.syndrome<6> = if SoftwareStep_SteppedEX() then '1' else '0';
    exception.syndrome<5:0> = '100010'; // IFSC = Debug Exception

    if PSTATE.EL == EL2 || route_to_el2 then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/debug/AArch64.VectorCatchException

```
// AArch64.VectorCatchException()
// =====
// Vector Catch taken from EL0 or EL1 to EL2. This can only be called when debug exceptions are
// being routed to EL2, as Vector Catch is a legacy debug event.

AArch64.VectorCatchException(FaultRecord fault)
    assert PSTATE.EL != EL2;
    assert EL2Enabled() && (HCR_EL2.TGE == '1' || MDCR_EL2.TDE == '1');

    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x0;

    vaddress = bits(64) UNKNOWN;
    exception = AArch64.AbortSyndrome(Exception_VectorCatch, fault, vaddress);

    AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/debug/AArch64.WatchpointException

```
// AArch64.WatchpointException()
// =====

AArch64.WatchpointException(bits(64) vaddress, FaultRecord fault)
    assert PSTATE.EL != EL3;

    route_to_el2 = (PSTATE.EL IN {EL0, EL1} && EL2Enabled\(\) &&
        (HCR_EL2.TGE == '1' || MDCR_EL2.TDE == '1'));

    bits(64) preferred_exception_return = ThisInstrAddr\(\);
    vect_offset = 0x0;

    if HaveNV2Ext\(\) && fault.acctype == AccType\_NV2REGISTER then
        exception = AArch64.AbortSyndrome(Exception\_NV2Watchpoint, fault, vaddress);
    else
        exception = AArch64.AbortSyndrome(Exception\_Watchpoint, fault, vaddress);

    if PSTATE.EL == EL2 || route_to_el2 then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/exceptions/AArch64.ExceptionClass

```
// AArch64.ExceptionClass()
// =====
// Returns the Exception Class and Instruction Length fields to be reported in ESR

(integer,bit) AArch64.ExceptionClass(Exception exceptype, bits(2) target_el)

    il_is_valid = TRUE;
    from_32 = UsingAArch32();

    case exceptype of
        when Exception_Uncategorized          ec = 0x00; il_is_valid = FALSE;
        when Exception_WFxTrap                ec = 0x01;
        when Exception_CP15RRTTrap            ec = 0x03; assert from_32;
        when Exception_CP15RRTTrap            ec = 0x04; assert from_32;
        when Exception_CP14RRTTrap            ec = 0x05; assert from_32;
        when Exception_CP14DTTrap             ec = 0x06; assert from_32;
        when Exception_AdvSIMDFPAccessTrap    ec = 0x07;
        when Exception_FPIDTrap               ec = 0x08;
        when Exception_PACTrap                 ec = 0x09;
        when Exception_LDST64BTrap            ec = 0x0A;
        when Exception_CP14RRTTrap            ec = 0x0C; assert from_32;
        when Exception_BranchTarget           ec = 0x0D;
        when Exception_IllegalState           ec = 0x0E; il_is_valid = FALSE;
        when Exception_SupervisorCall         ec = 0x11;
        when Exception_HypervisorCall         ec = 0x12;
        when Exception_MonitorCall            ec = 0x13;
        when Exception_SystemRegisterTrap     ec = 0x18; assert !from_32;
        when Exception_SVEAccessTrap          ec = 0x19; assert !from_32;
        when Exception_ERetTrap               ec = 0x1A; assert !from_32;
        when Exception_PACFail                ec = 0x1C; assert !from_32;
        when Exception_InstructionAbort       ec = 0x20; il_is_valid = FALSE;
        when Exception_PCAlignment           ec = 0x22; il_is_valid = FALSE;
        when Exception_DataAbort              ec = 0x24;
        when Exception_NV2DataAbort           ec = 0x25;
        when Exception_SPAlignment            ec = 0x26; il_is_valid = FALSE; assert !from_32;
        when Exception_FPtrappedException     ec = 0x28;
        when Exception_SError                 ec = 0x2F; il_is_valid = FALSE;
        when Exception_Breakpoint             ec = 0x30; il_is_valid = FALSE;
        when Exception_SoftwareStep           ec = 0x32; il_is_valid = FALSE;
        when Exception_Watchpoint             ec = 0x34; il_is_valid = FALSE;
        when Exception_NV2Watchpoint          ec = 0x35; il_is_valid = FALSE;
        when Exception_SoftwareBreakpoint     ec = 0x38;
        when Exception_VectorCatch            ec = 0x3A; il_is_valid = FALSE; assert from_32;
        otherwise                             Unreachable();

    if ec IN {0x20,0x24,0x30,0x32,0x34} && target_el == PSTATE.EL then
        ec = ec + 1;

    if ec IN {0x11,0x12,0x13,0x28,0x38} && !from_32 then
        ec = ec + 4;

    if il_is_valid then
        il = if ThisInstrLength() == 32 then '1' else '0';
    else
        il = '1';
    assert from_32 || il == '1'; // AArch64 instructions always 32-bit

    return (ec,il);
```

## Library pseudocode for aarch64/exceptions/exceptions/AArch64.ReportException

```
// AArch64.ReportException()
// =====
// Report syndrome information for exception taken to AArch64 state.

AArch64.ReportException(ExceptionRecord exception, bits(2) target_el)

    Exception exceptype = exception.exceptype;

    (ec,il) = AArch64.ExceptionClass(exceptype, target_el);
    iss = exception.syndrome;
    iss2 = exception.syndrome2;

    // IL is not valid for Data Abort exceptions without valid instruction syndrome information
    if ec IN {0x24,0x25} && iss<24> == '0' then
        il = '1';

    ESR[target_el] = (Zeros(27) :    // <63:37>
                     iss2          :    // <36:32>
                     ec<5:0>       :    // <31:26>
                     il            :    // <25>
                     iss);          // <24:0>

    if exceptype IN {
        Exception_InstructionAbort,
        Exception_PCAlignment,
        Exception_DataAbort,
        Exception_NV2DataAbort,
        Exception_NV2Watchpoint,
        Exception_Watchpoint
    } then
        FAR[target_el] = exception.vaddress;
    else
        FAR[target_el] = bits(64) UNKNOWN;

    if exception.ipavalid then
        HPFAR_EL2<43:4> = exception.ipaddress<51:12>;
        if IsSecureEL2Enabled() && IsSecure() then
            HPFAR_EL2.NS = exception.NS;
        else
            HPFAR_EL2.NS = '0';
    elsif target_el == EL2 then
        HPFAR_EL2<43:4> = bits(40) UNKNOWN;

    return;
```

## Library pseudocode for aarch64/exceptions/exceptions/AArch64.ResetControlRegisters

```
// Resets System registers and memory-mapped control registers that have architecturally-defined
// reset values to those values.
AArch64.ResetControlRegisters(boolean cold_reset);
```



## Library pseudocode for aarch64/exceptions/exceptions/AArch64.TakeReset

```
// AArch64.TakeReset()
// =====
// Reset into AArch64 state

AArch64.TakeReset(boolean cold_reset)
    assert !HighestELUsingAArch32\(\);

    // Enter the highest implemented Exception level in AArch64 state
    PSTATE.nRW = '0';
    if HaveEL\(EL3\) then
        PSTATE.EL = EL3;
    elsif HaveEL\(EL2\) then
        PSTATE.EL = EL2;
    else
        PSTATE.EL = EL1;

    // Reset the system registers and other system components
    AArch64.ResetControlRegisters(cold_reset);

    // Reset all other PSTATE fields
    PSTATE.SP = '1';           // Select stack pointer
    PSTATE.<D,A,I,F> = '1111'; // All asynchronous exceptions masked
    PSTATE.SS = '0';           // Clear software step bit
    PSTATE.DIT = '0';          // PSTATE.DIT is reset to 0 when resetting into AArch64
    PSTATE.IL = '0';           // Clear Illegal Execution state bit

    // All registers, bits and fields not reset by the above pseudocode or by the BranchTo() call
    // below are UNKNOWN bitstrings after reset. In particular, the return information registers
    // ELR_ELx and SPSR_ELx have UNKNOWN values, so that it
    // is impossible to return from a reset in an architecturally defined way.
    AArch64.ResetGeneralRegisters();
    AArch64.ResetSIMDFPRegisters();
    AArch64.ResetSpecialRegisters();
    ResetExternalDebugRegisters(cold_reset);

    bits(64) rv;               // IMPLEMENTATION DEFINED reset vector

    if HaveEL\(EL3\) then
        rv = RVBAR_EL3;
    elsif HaveEL\(EL2\) then
        rv = RVBAR_EL2;
    else
        rv = RVBAR_EL1;

    // The reset vector must be correctly aligned
    assert IsZero(rv<63:AArch64.PAMax()>) && IsZero(rv<1:0>);

    boolean branch_conditional = FALSE;
    BranchTo(rv, BranchType\_RESET, branch_conditional);
```

## Library pseudocode for aarch64/exceptions/ieeefp/AArch64.FPTrappedException

```
// AArch64.FPTrappedException()
// =====

AArch64.FPTrappedException(boolean is_ase, bits(8) accumulated_exceptions)
    exception = ExceptionSyndrome\(Exception\_FPTrappedException\);
    if is_ase then
        if boolean IMPLEMENTATION_DEFINED "vector instructions set TFV to 1" then
            exception.syndrome<23> = '1'; // TFV
        else
            exception.syndrome<23> = '0'; // TFV
    else
        exception.syndrome<23> = '1'; // TFV
    exception.syndrome<10:8> = bits(3) UNKNOWN; // VECITR
    if exception.syndrome<23> == '1' then
        exception.syndrome<7,4:0> = accumulated_exceptions<7,4:0>; // IDF,IXF,UFF,OFF,DZF,IOf
    else
        exception.syndrome<7,4:0> = bits(6) UNKNOWN;

    route_to_el2 = EL2Enabled\(\) && HCR_EL2.TGE == '1';

    bits(64) preferred_exception_return = ThisInstrAddr\(\);
    vect_offset = 0x0;

    if UInt\(PSTATE.EL\) > UInt\(EL1\) then
        AArch64.TakeException(PSTATE.EL, exception, preferred_exception_return, vect_offset);
    elsif route_to_el2 then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/syscalls/AArch64.CallHypervisor

```
// AArch64.CallHypervisor()
// =====
// Performs a HVC call

AArch64.CallHypervisor(bits(16) immediate)
    assert HaveEL\(EL2\);

    if UsingAArch32\(\) then AArch32.ITAdvance\(\);
    SSAdvance\(\);
    bits(64) preferred_exception_return = NextInstrAddr\(\);
    vect_offset = 0x0;

    exception = ExceptionSyndrome\(Exception\_HypervisorCall\);
    exception.syndrome<15:0> = immediate;

    if PSTATE.EL == EL3 then
        AArch64.TakeException(EL3, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/syscalls/AArch64.CallSecureMonitor

```
// AArch64.CallSecureMonitor()
// =====

AArch64.CallSecureMonitor(bits(16) immediate)
    assert HaveEL(EL3) && !ELUsingAArch32(EL3);
    if UsingAArch32() then AArch32.ITAdvance();
    SSAdvance();
    bits(64) preferred_exception_return = NextInstrAddr();
    vect_offset = 0x0;

    exception = ExceptionSyndrome(Exception_MonitorCall);
    exception.syndrome<15:0> = immediate;

    AArch64.TakeException(EL3, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/syscalls/AArch64.CallSupervisor

```
// AArch64.CallSupervisor()
// =====
// Calls the Supervisor

AArch64.CallSupervisor(bits(16) immediate)

    if UsingAArch32() then AArch32.ITAdvance();
    SSAdvance();
    route_to_el2 = PSTATE.EL == EL0 && EL2Enabled() && HCR_EL2.TGE == '1';

    bits(64) preferred_exception_return = NextInstrAddr();
    vect_offset = 0x0;

    exception = ExceptionSyndrome(Exception_SupervisorCall);
    exception.syndrome<15:0> = immediate;

    if UInt(PSTATE.EL) > UInt(EL1) then
        AArch64.TakeException(PSTATE.EL, exception, preferred_exception_return, vect_offset);
    elsif route_to_el2 then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```



```

// AArch64.TakeException()
// =====
// Take an exception to an Exception level using AArch64.

AArch64.TakeException(bits(2) target_el, ExceptionRecord exception,
                      bits(64) preferred_exception_return, integer vect_offset)
assert HaveEL(target_el) && !ELUsingAArch32(target_el) && UInt(target_el) >= UInt(PSTATE.EL);

if HaveIESB() then
    sync_errors = SCTLR[target_el].IESB == '1';
    if HaveDoubleFaultExt() then
        sync_errors = sync_errors || (SCR\_EL3.<EA,NMEA> == '11' && target_el == EL3);
    if sync_errors && InsertIESBBeforeException(target_el) then
        SynchronizeErrors();
        iesb_req = FALSE;
        sync_errors = FALSE;
        TakeUnmaskedPhysicalSErrorInterrupts(iesb_req);
else
    sync_errors = FALSE;

SynchronizeContext();

// If coming from AArch32 state, the top parts of the X[] registers might be set to zero
from_32 = UsingAArch32();
if from_32 then AArch64.MaybeZeroRegisterUppers();
MaybeZeroSVEUppers(target_el);

if UInt(target_el) > UInt(PSTATE.EL) then
    boolean lower_32;
    if target_el == EL3 then
        if EL2Enabled() then
            lower_32 = ELUsingAArch32(EL2);
        else
            lower_32 = ELUsingAArch32(EL1);
    elsif IsInHost() && PSTATE.EL == EL0 && target_el == EL2 then
        lower_32 = ELUsingAArch32(EL0);
    else
        lower_32 = ELUsingAArch32(target_el - 1);
    vect_offset = vect_offset + (if lower_32 then 0x600 else 0x400);

elsif PSTATE.SP == '1' then
    vect_offset = vect_offset + 0x200;

bits(64) spsr = GetPSRFromPSTATE(AArch64\_NonDebugState);

if PSTATE.EL == EL1 && target_el == EL1 && EL2Enabled() then
    if HaveNV2Ext() && (HCR\_EL2.<NV,NV1,NV2> == '100' || HCR\_EL2.<NV,NV1,NV2> == '111') then
        spsr<3:2> = '10';
    else
        if HaveNVExt() && HCR\_EL2.<NV,NV1> == '10' then
            spsr<3:2> = '10';

if HaveBTIExt() && !UsingAArch32() then
    // SPSR[].BTYP is only guaranteed valid for these exception types
    if exception.exceptype IN {Exception\_SError, Exception\_IRQ, Exception\_FIQ,
                             Exception\_SoftwareStep, Exception\_PCAlignment,
                             Exception\_InstructionAbort, Exception\_Breakpoint,
                             Exception\_VectorCatch, Exception\_SoftwareBreakpoint,
                             Exception\_IllegalState, Exception\_BranchTarget} then
        zero_btype = FALSE;
    else
        zero_btype = ConstrainUnpredictableBool(Unpredictable\_ZEROBTYP);
    if zero_btype then spsr<11:10> = '00';

if HaveNV2Ext() && exception.exceptype == Exception\_NV2DataAbort && target_el == EL3 then
    // External aborts are configured to be taken to EL3
    exception.exceptype = Exception\_DataAbort;
if !(exception.exceptype IN {Exception\_IRQ, Exception\_FIQ}) then
    AArch64.ReportException(exception, target_el);

```

```

PSTATE.EL = target_el;
PSTATE.nRW = '0';
PSTATE.SP = '1';

SPSR[] = spsr;
ELR[] = preferred_exception_return;

PSTATE.SS = '0';
PSTATE.<D,A,I,F> = '1111';
PSTATE.IL = '0';
if from_32 then // Coming from AArch32
    PSTATE.IT = '00000000';
    PSTATE.T = '0'; // PSTATE.J is RES0
if (HavePANExt() && (PSTATE.EL == EL1 || (PSTATE.EL == EL2 && ELIsInHost(EL0))) &&
    SCTLR[].SPAN == '0') then
    PSTATE.PAN = '1';
if HaveUA0Ext() then PSTATE.UA0 = '0';
if HaveBTIExt() then PSTATE.BTYPE = '00';
if HaveSSBSExt() then PSTATE.SSBS = SCTLR[].DSSBS;
if HaveMTEExt() then PSTATE.TCO = '1';

boolean branch_conditional = FALSE;
BranchTo(VBAR[]<63:11>:vect_offset<10:0>, BranchType_EXCEPTION, branch_conditional);

if sync_errors then
    SynchronizeErrors();
    iesb_req = TRUE;
    TakeUnmaskedPhysicalSErrorInterrupts(iesb_req);

EndOfInstruction();

```

### Library pseudocode for aarch64/exceptions/traps/AArch64.AArch32SystemAccessTrap

```

// AArch64.AArch32SystemAccessTrap()
// =====
// Trapped AARCH32 system register access.

AArch64.AArch32SystemAccessTrap(bits(2) target_el, integer ec)
    assert HaveEL(target_el) && target_el != EL0 && UInt(target_el) >= UInt(PSTATE.EL);

    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x0;

    exception = AArch64.AArch32SystemAccessTrapSyndrome(ThisInstr(), ec);
    AArch64.TakeException(target_el, exception, preferred_exception_return, vect_offset);

```



```

// AArch64.AArch32SystemAccessTrapSyndrome()
// =====
// Returns the syndrome information for traps on AArch32 MCR, MCRR, MRC, MRRC, and VMRS, VMSR instructions
// other than traps that are due to HCPTR or CPACR.

ExceptionRecord AArch64.AArch32SystemAccessTrapSyndrome(bits(32) instr, integer ec)
    ExceptionRecord exception;

    case ec of
        when 0x0    exception = ExceptionSyndrome(Exception_Uncategorized);
        when 0x3    exception = ExceptionSyndrome(Exception_CP15RTTTrap);
        when 0x4    exception = ExceptionSyndrome(Exception_CP15RRTTrap);
        when 0x5    exception = ExceptionSyndrome(Exception_CP14RTTTrap);
        when 0x6    exception = ExceptionSyndrome(Exception_CP14DTTTrap);
        when 0x7    exception = ExceptionSyndrome(Exception_AdvSIMDFPAccessTrap);
        when 0x8    exception = ExceptionSyndrome(Exception_FPIDTrap);
        when 0xC    exception = ExceptionSyndrome(Exception_CP14RRTTrap);
        otherwise   Unreachable();

    bits(20) iss = Zeros();

    if exception.exceptype IN {Exception_FPIDTrap, Exception_CP14RTTTrap, Exception_CP15RTTTrap} then
        // Trapped MRC/MCR, VMRS on FPSID
        if exception.exceptype != Exception_FPIDTrap then // When trap is not for VMRS
            iss<19:17> = instr<7:5>; // opc2
            iss<16:14> = instr<23:21>; // opc1
            iss<13:10> = instr<19:16>; // CRn
            iss<4:1> = instr<3:0>; // CRm
        else
            iss<19:17> = '000';
            iss<16:14> = '111';
            iss<13:10> = instr<19:16>; // reg
            iss<4:1> = '0000';

            if instr<20> == '1' && instr<15:12> == '1111' then // MRC, Rt==15
                iss<9:5> = '11111';
            elsif instr<20> == '0' && instr<15:12> == '1111' then // MCR, Rt==15
                iss<9:5> = bits(5) UNKNOWN;
            else
                iss<9:5> = LookUpRIndex(UInt(instr<15:12>), PSTATE.M)<4:0>;
        elsif exception.exceptype IN {Exception_CP14RRTTrap, Exception_AdvSIMDFPAccessTrap, Exception_CP15RRTTrap} then
            // Trapped MRRC/MCRR, VMRS/VMSR
            iss<19:16> = instr<7:4>; // opc1
            if instr<19:16> == '1111' then // Rt2==15
                iss<14:10> = bits(5) UNKNOWN;
            else
                iss<14:10> = LookUpRIndex(UInt(instr<19:16>), PSTATE.M)<4:0>;

            if instr<15:12> == '1111' then // Rt==15
                iss<9:5> = bits(5) UNKNOWN;
            else
                iss<9:5> = LookUpRIndex(UInt(instr<15:12>), PSTATE.M)<4:0>;
            iss<4:1> = instr<3:0>; // CRm
        elsif exception.exceptype == Exception_CP14DTTTrap then
            // Trapped LDC/STC
            iss<19:12> = instr<7:0>; // imm8
            iss<4> = instr<23>; // U
            iss<2:1> = instr<24,21>; // P,W
            if instr<19:16> == '1111' then // Rn==15, LDC(Literal addressing)/STC
                iss<9:5> = bits(5) UNKNOWN;
                iss<3> = '1';
            elsif exception.exceptype == Exception_Uncategorized then
                // Trapped for unknown reason
                iss<9:5> = LookUpRIndex(UInt(instr<19:16>), PSTATE.M)<4:0>; // Rn
                iss<3> = '0';

        iss<0> = instr<20>; // Direction

    exception.syndrome<24:20> = ConditionSyndrome();
    exception.syndrome<19:0> = iss;

```



```
return exception;
```

### Library pseudocode for aarch64/exceptions/traps/AArch64.AdvSIMDFPAccessTrap

```
// AArch64.AdvSIMDFPAccessTrap()
// =====
// Trapped access to Advanced SIMD or FP registers due to CPACR[].

AArch64.AdvSIMDFPAccessTrap(bits(2) target_el)
    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x0;

    route_to_el2 = (target_el == EL1 && EL2Enabled() && HCR_EL2.TGE == '1');

    if route_to_el2 then
        exception = ExceptionSyndrome(Exception_Uncategorized);
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        exception = ExceptionSyndrome(Exception_AdvSIMDFPAccessTrap);
        exception.syndrome<24:20> = ConditionSyndrome();
        AArch64.TakeException(target_el, exception, preferred_exception_return, vect_offset);

    return;
```

### Library pseudocode for aarch64/exceptions/traps/AArch64.CheckCP15InstrCoarseTraps

```
// AArch64.CheckCP15InstrCoarseTraps()
// =====
// Check for coarse-grained AArch32 CP15 traps in HSTR_EL2 and HCR_EL2.

boolean AArch64.CheckCP15InstrCoarseTraps(integer CRn, integer nreg, integer CRm)

    // Check for coarse-grained Hyp traps
    if PSTATE.EL IN {EL0, EL1} && EL2Enabled() then
        // Check for MCR, MRC, MCRR and MRRC disabled by HSTR_EL2<CRn/CRm>
        major = if nreg == 1 then CRn else CRm;
        if !IsInHost() && !(major IN {4,14}) && HSTR_EL2<major> == '1' then
            return TRUE;

        // Check for MRC and MCR disabled by HCR_EL2.TIDCP
        if (HCR_EL2.TIDCP == '1' && nreg == 1 &&
            ((CRn == 9 && CRm IN {0,1,2, 5,6,7,8 }) ||
             (CRn == 10 && CRm IN {0,1, 4, 8 }) ||
             (CRn == 11 && CRm IN {0,1,2,3,4,5,6,7,8,15}))) then
            return TRUE;

    return FALSE;
```

### Library pseudocode for aarch64/exceptions/traps/AArch64.CheckFPAdvSIMDEnabled

```
// AArch64.CheckFPAdvSIMDEnabled()
// =====
// Check against CPACR[]

AArch64.CheckFPAdvSIMDEnabled()
    if PSTATE.EL IN {EL0, EL1} && !IsInHost() then
        // Check if access disabled in CPACR_EL1
        case CPACR_EL1.FPEN of
            when 'x0' disabled = TRUE;
            when '01' disabled = PSTATE.EL == EL0;
            when '11' disabled = FALSE;
        if disabled then AArch64.AdvSIMDFPAccessTrap(EL1);

    AArch64.CheckFPAdvSIMDTrap(); // Also check against CPTR_EL2 and CPTR_EL3
```

## Library pseudocode for aarch64/exceptions/traps/AArch64.CheckFPAdvSIMDTrap

```
// AArch64.CheckFPAdvSIMDTrap()
// =====
// Check against CPTR_EL2 and CPTR_EL3.

AArch64.CheckFPAdvSIMDTrap()
    if PSTATE.EL IN {EL0, EL1, EL2} && EL2Enabled() then
        // Check if access disabled in CPTR_EL2
        if HaveVirtHostExt() && HCR_EL2.E2H == '1' then
            case CPTR_EL2.FPEN of
                when 'x0' disabled = TRUE;
                when '01' disabled = PSTATE.EL == EL0 && HCR_EL2.TGE == '1';
                when '11' disabled = FALSE;
            if disabled then AArch64.AdvSIMDFPAccessTrap(EL2);
        else
            if CPTR_EL2.TFP == '1' then AArch64.AdvSIMDFPAccessTrap(EL2);

    if HaveEL(EL3) then
        // Check if access disabled in CPTR_EL3
        if CPTR_EL3.TFP == '1' then AArch64.AdvSIMDFPAccessTrap(EL3);

    return;
```

## Library pseudocode for aarch64/exceptions/traps/AArch64.CheckForERetTrap

```
// AArch64.CheckForERetTrap()
// =====
// Check for trap on ERET, ERETAA, ERETAB instruction

AArch64.CheckForERetTrap(boolean eret_with_pac, boolean pac_uses_key_a)

    route_to_el2 = FALSE;
    // Non-secure EL1 execution of ERET, ERETAA, ERETAB when either HCR_EL2.NV or HFGITR_EL2.ERET is set,
    // is trapped to EL2
    route_to_el2 = (PSTATE.EL == EL1 && EL2Enabled() &&
        ((HaveNVExt() && HCR_EL2.NV == '1') ||
        (HaveFGTExt() && HCR_EL2.<E2H, TGE> != '11' &&
        (!HaveEL(EL3) || SCR_EL3.FGTEn == '1') && HFGITR_EL2.ERET == '1')));
    if route_to_el2 then
        ExceptionRecord exception;
        bits(64) preferred_exception_return = ThisInstrAddr();
        vect_offset = 0x0;
        exception = ExceptionSyndrome(Exception_ERetTrap);
        if !eret_with_pac then // ERET
            exception.syndrome<1> = '0';
            exception.syndrome<0> = '0'; // RES0
        else
            exception.syndrome<1> = '1';
            if pac_uses_key_a then // ERETAA
                exception.syndrome<0> = '0';
            else // ERETAB
                exception.syndrome<0> = '1';
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/traps/AArch64.CheckForSMCUnDefOrTrap

```
// AArch64.CheckForSMCUnDefOrTrap()
// =====
// Check for UNDEFINED or trap on SMC instruction

AArch64.CheckForSMCUnDefOrTrap(bits(16) imm)
    if PSTATE.EL == EL0 then UNDEFINED;
    if (!(PSTATE.EL == EL1 && EL2Enabled() && HCR_EL2.TSC == '1') &&
        HaveEL(EL3) && SCR_EL3.SMD == '1') then
        UNDEFINED;
    route_to_el2 = FALSE;
    if !HaveEL(EL3) then
        if PSTATE.EL == EL1 && EL2Enabled() then
            if HaveNVExt() && HCR_EL2.NV == '1' && HCR_EL2.TSC == '1' then
                route_to_el2 = TRUE;
            else
                UNDEFINED;
        else
            UNDEFINED;
    else
        route_to_el2 = PSTATE.EL == EL1 && EL2Enabled() && HCR_EL2.TSC == '1';
    if route_to_el2 then
        bits(64) preferred_exception_return = ThisInstrAddr();
        vect_offset = 0x0;
        exception = ExceptionSyndrome(Exception_MonitorCall);
        exception.syndrome<15:0> = imm;
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/traps/AArch64.CheckForSVCTrap

```
// AArch64.CheckForSVCTrap()
// =====
// Check for trap on SVC instruction

AArch64.CheckForSVCTrap(bits(16) immediate)
    if HaveFGTExt() then
        route_to_el2 = FALSE;
        if PSTATE.EL == EL0 then
            route_to_el2 = (!ELUsingAArch32(EL0) && !ELUsingAArch32(EL1) && EL2Enabled() && HFGITR_EL2.SVC_EL1 == '1' &&
                (HCR_EL2.<E2H, TGE> != '11' && (!HaveEL(EL3) || SCR_EL3.FGTEn == '1')));
        elsif PSTATE.EL == EL1 then
            route_to_el2 = (!ELUsingAArch32(EL1) && EL2Enabled() && HFGITR_EL2.SVC_EL1 == '1' &&
                (HCR_EL2.<E2H, TGE> != '11' && (!HaveEL(EL3) || SCR_EL3.FGTEn == '1')));
    if route_to_el2 then
        exception = ExceptionSyndrome(Exception_SupervisorCall);
        exception.syndrome<15:0> = immediate;
        bits(64) preferred_exception_return = ThisInstrAddr();
        vect_offset = 0x0;
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/traps/AArch64.CheckForWfxTrap

```
// AArch64.CheckForWfxTrap()
// =====
// Check for trap on WFE or WFI instruction

AArch64.CheckForWfxTrap(bits(2) target_el, WfxType wfxtype)
    assert HaveEL(target_el);

    boolean is_wfe = wfxtype IN {WfxType_WFE, WfxType_WFET};
    case target_el of
        when EL1
            trap = (if is_wfe then SCTLRL[].nTWE else SCTLRL[].nTWI) == '0';
        when EL2
            trap = (if is_wfe then HCR_EL2.TWE else HCR_EL2.TWI) == '1';
        when EL3
            trap = (if is_wfe then SCR_EL3.TWE else SCR_EL3.TWI) == '1';

    if trap then
        AArch64.WfxTrap(wfxtype, target_el);
```

## Library pseudocode for aarch64/exceptions/traps/AArch64.CheckIllegalState

```
// AArch64.CheckIllegalState()
// =====
// Check PSTATE.IL bit and generate Illegal Execution state exception if set.

AArch64.CheckIllegalState()
    if PSTATE.IL == '1' then
        route_to_el2 = PSTATE.EL == EL0 && EL2Enabled() && HCR_EL2.TGE == '1';

        bits(64) preferred_exception_return = ThisInstrAddr();
        vect_offset = 0x0;

        exception = ExceptionSyndrome(Exception_IllegalState);

        if UInt(PSTATE.EL) > UInt(EL1) then
            AArch64.TakeException(PSTATE.EL, exception, preferred_exception_return, vect_offset);
        elsif route_to_el2 then
            AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
        else
            AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/traps/AArch64.MonitorModeTrap

```
// AArch64.MonitorModeTrap()
// =====
// Trapped use of Monitor mode features in a Secure EL1 AArch32 mode

AArch64.MonitorModeTrap()
    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x0;

    exception = ExceptionSyndrome(Exception_Uncategorized);

    if IsSecureEL2Enabled() then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    AArch64.TakeException(EL3, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/traps/AArch64.SystemAccessTrap

```
// AArch64.SystemAccessTrap()
// =====
// Trapped access to AArch64 system register or system instruction.

AArch64.SystemAccessTrap(bits(2) target_el, integer ec)
    assert HaveEL(target_el) && target_el != EL0 && UInt(target_el) >= UInt(PSTATE.EL);

    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x0;

    exception = AArch64.SystemAccessTrapSyndrome(ThisInstr(), ec);
    AArch64.TakeException(target_el, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/traps/AArch64.SystemAccessTrapSyndrome

```
// AArch64.SystemAccessTrapSyndrome()
// =====
// Returns the syndrome information for traps on AArch64 MSR/MRS instructions.

ExceptionRecord AArch64.SystemAccessTrapSyndrome(bits(32) instr, integer ec)
    ExceptionRecord exception;
    case ec of
        when 0x0 // Trapped access due to unknown reason
            exception = ExceptionSyndrome(Exception_Uncategorized);
        when 0x7 // Trapped access to SVE, Advance SIMD instructions
            exception = ExceptionSyndrome(Exception_AdvSIMDFPAccessTrap);
            exception.syndrome<24:20> = ConditionSyndrome();
        when 0x18 // Trapped access to system register
            exception = ExceptionSyndrome(Exception_SystemRegisterTrap);
            instr = ThisInstr();
            exception.syndrome<21:20> = instr<20:19>; // Op0
            exception.syndrome<19:17> = instr<7:5>; // Op2
            exception.syndrome<16:14> = instr<18:16>; // Op1
            exception.syndrome<13:10> = instr<15:12>; // CRn
            exception.syndrome<9:5> = instr<4:0>; // Rt
            exception.syndrome<4:1> = instr<11:8>; // CRm
            exception.syndrome<0> = instr<21>; // Direction
        when 0x19 // Trapped access to SVE System register
            exception = ExceptionSyndrome(Exception_SVEAccessTrap);
        otherwise
            Unreachable();

    return exception;
```

## Library pseudocode for aarch64/exceptions/traps/AArch64.UndefinedFault

```
// AArch64.UndefinedFault()
// =====

AArch64.UndefinedFault()

    route_to_el2 = PSTATE.EL == EL0 && EL2Enabled() && HCR_EL2.TGE == '1';
    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x0;

    exception = ExceptionSyndrome(Exception_Uncategorized);

    if UInt(PSTATE.EL) > UInt(EL1) then
        AArch64.TakeException(PSTATE.EL, exception, preferred_exception_return, vect_offset);
    elsif route_to_el2 then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/traps/AArch64.WFxTrap

```
// AArch64.WFxTrap()
// =====

AArch64.WFxTrap(WFxType wfxtype, bits(2) target_el)
    assert UInt(target_el) > UInt(PSTATE.EL);

    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x0;

    exception = ExceptionSyndrome(Exception_WFxTrap);
    exception.syndrome<24:20> = ConditionSyndrome();

    case wfxtype of
        when WFxType_WFI
            exception.syndrome<1:0> = '00';
        when WFxType_WFE
            exception.syndrome<1:0> = '01';
        when WFxType_WFIT
            exception.syndrome<1:0> = '10';
        when WFxType_WFET
            exception.syndrome<1:0> = '11';

    if target_el == EL1 && EL2Enabled() && HCR_EL2.TGE == '1' then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(target_el, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/traps/CheckFPAdvSIMDEnabled64

```
// CheckFPAdvSIMDEnabled64()
// =====
// AArch64 instruction wrapper

CheckFPAdvSIMDEnabled64()
    AArch64.CheckFPAdvSIMDEnabled();
```

## Library pseudocode for aarch64/exceptions/traps/CheckLDST64BEnabled

```
// CheckLDST64BEnabled()
// =====
// Checks for trap on ST64B and LD64B instructions

CheckLDST64BEnabled()
    boolean trap = FALSE;
    bits(25) iss = ZeroExtend('10'); // 0x2

    if PSTATE.EL == EL0 then
        if !IsInHost() then
            trap = SCTLR_EL1.EnALS == '0';
            target_el = if HCR_EL2.TGE == '1' then EL2 else EL1;
        else
            trap = SCTLR_EL2.EnALS == '0';
            target_el = EL2;

    if (!trap && EL2Enabled() && HaveFeatHCX() &&
        ((PSTATE.EL == EL0 && !IsInHost()) || PSTATE.EL == EL1)) then
        trap = !IsHCRXEL2Enabled() || HCRX_EL2.EnALS == '0';
        target_el = EL2;

    if trap then LDST64BTrap(target_el, iss);
```

## Library pseudocode for aarch64/exceptions/traps/CheckST64BV0Enabled

```
// CheckST64BV0Enabled()
// =====
// Checks for trap on ST64BV0 instruction

CheckST64BV0Enabled()
    boolean trap = FALSE;
    bits(25) iss = ZeroExtend('1'); // 0x1

    if PSTATE.EL == EL0 then
        if !IsInHost() then
            trap = SCTLR_EL1.EnAS0 == '0';
            target_el = if HCR_EL2.TGE == '1' then EL2 else EL1;
        else
            trap = SCTLR_EL2.EnAS0 == '0';
            target_el = EL2;

    if (!trap && EL2Enabled() && HaveFeatHXCX() &&
        ((PSTATE.EL == EL0 && !IsInHost()) || PSTATE.EL == EL1)) then
        trap = !IsHCRXEL2Enabled() || HCRX_EL2.EnAS0 == '0';
        target_el = EL2;

    if !trap && PSTATE.EL != EL3 then
        trap = HaveEL(EL3) && SCR_EL3.EnAS0 == '0';
        target_el = EL3;

    if trap then LDST64BTrap(target_el, iss);
```

## Library pseudocode for aarch64/exceptions/traps/CheckST64BVEnabled

```
// CheckST64BVEnabled()
// =====
// Checks for trap on ST64BV instruction

CheckST64BVEnabled()
    boolean trap = FALSE;
    bits(25) iss = Zeros();

    if PSTATE.EL == EL0 then
        if !IsInHost() then
            trap = SCTLR_EL1.EnASR == '0';
            target_el = if HCR_EL2.TGE == '1' then EL2 else EL1;
        else
            trap = SCTLR_EL2.EnASR == '0';
            target_el = EL2;

    if (!trap && EL2Enabled() && HaveFeatHXCX() &&
        ((PSTATE.EL == EL0 && !IsInHost()) || PSTATE.EL == EL1)) then
        trap = !IsHCRXEL2Enabled() || HCRX_EL2.EnASR == '0';
        target_el = EL2;

    if trap then LDST64BTrap(target_el, iss);
```

## Library pseudocode for aarch64/exceptions/traps/LDST64BTrap

```
// LDST64BTrap()
// =====
// Trapped access to LD64B, ST64B, ST64BV and ST64BV0 instructions

LDST64BTrap(bits(2) target_el, bits(25) iss)
    bits(64) preferred_exception_return = ThisInstrAddr\(\);
    vect_offset = 0x0;

    exception = ExceptionSyndrome(Exception\_LDST64BTrap);
    exception.syndrome = iss;
    AArch64.TakeException(target_el, exception, preferred_exception_return, vect_offset);

    return;
```

## Library pseudocode for aarch64/exceptions/traps/WFETrapDelay

```
// WFETrapDelay()
// =====
// Returns TRUE when delay in trap to WFE is enabled with value to amount of delay,
// FALSE otherwise.

(boolean, integer) WFETrapDelay(bits(2) target_el)
    case target_el of
        when EL1
            if !IsInHost() then
                delay_enabled = SCTLR_EL1.TWEDEn == '1';
                delay          = 1 << (UInt(SCTLR_EL1.TWEDEL) + 8);
            else
                delay_enabled = SCTLR_EL2.TWEDEn == '1';
                delay          = 1 << (UInt(SCTLR_EL2.TWEDEL) + 8);
        when EL2
            delay_enabled = HCR_EL2.TWEDEn == '1';
            delay          = 1 << (UInt(HCR_EL2.TWEDEL) + 8);
        when EL3
            delay_enabled = SCR_EL3.TWEDEn == '1';
            delay          = 1 << (UInt(SCR_EL3.TWEDEL) + 8);

    return (delay_enabled, delay);
```

## Library pseudocode for aarch64/exceptions/traps/WaitForEventUntilDelay

```
// WaitForEventUntilDelay()
// =====
// Returns TRUE if WaitForEvent() returns before WFE trap delay expires,
// FALSE otherwise.

boolean WaitForEventUntilDelay(boolean delay_enabled, integer delay)
    boolean eventarrived = FALSE;
    // set eventarrived to TRUE if WaitForEvent() returns before
    // 'delay' expires when delay_enabled is TRUE.
    return eventarrived;
```



## Library pseudocode for aarch64/functions/aborts/AArch64.FaultSyndrome

```
// AArch64.FaultSyndrome()
// =====
// Creates an exception syndrome value for Abort and Watchpoint exceptions taken to
// an Exception level using AArch64.

(bits(25), bits(5)) AArch64.FaultSyndrome(boolean d_side, FaultRecord fault)
    assert fault.statuscode != Fault\_None;

    bits(25) iss = Zeros\(\);
    bits(5) iss2 = Zeros\(\);

    if !HaveFeatLS64\(\) && HaveRASExt\(\) && IsAsyncAbort(fault) then
        iss<12:11> = fault.errortype; // SET

    if d_side then
        if HaveFeatLS64\(\) && fault.acctype == AccType\_ATOMICLS64 then
            if (fault.statuscode IN {Fault\_AccessFlag,
Fault\_Translation, Fault\_Permission}) then
                (iss2, iss<24:14>, iss<12:11>) = LS64InstructionSyndrome\(\);
            else
                if (IsSecondStage(fault) && !fault.s2fslwalk &&
                    (!IsExternalSyncAbort(fault) ||
                     (!HaveRASExt\(\) && fault.acctype == AccType\_TTW &&
                      boolean IMPLEMENTATION_DEFINED "ISV on second stage translation table walk")))) then
                    iss<24:14> = LSInstructionSyndrome\(\);

                if HaveNV2Ext\(\) && fault.acctype == AccType\_NV2REGISTER then
                    iss<13> = '1'; // Fault is generated by use of VNCR_EL2

                if fault.acctype IN {AccType\_DC, AccType\_IC, AccType\_AT, AccType\_ATPAN} then
                    iss<8> = '1'; iss<6> = '1';
                else
                    iss<6> = if fault.write then '1' else '0';

                if IsExternalAbort(fault) then iss<9> = fault.extflag;
                iss<7> = if fault.s2fslwalk then '1' else '0';
                iss<5:0> = EncodeLDFSC(fault.statuscode, fault.level);

    return (iss, iss2);
```

## Library pseudocode for aarch64/functions/aborts/LS64InstructionSyndrome

```
// Returns the syndrome information and LST for a Data Abort by a
// ST64B, ST64BV, ST64BV0, or LD64B instruction. The syndrome information
// includes the ISS2, extended syndrome field, and LST.
(bits(5), bits(11), bits(2)) LS64InstructionSyndrome();
```

## Library pseudocode for aarch64/functions/exclusive/AArch64.ExclusiveMonitorsPass

```
// AArch64.ExclusiveMonitorsPass()
// =====
// Return TRUE if the Exclusives monitors for the current PE include all of the addresses
// associated with the virtual address region of size bytes starting at address.
// The immediately following memory write must be to the same addresses.

boolean AArch64.ExclusiveMonitorsPass(bits(64) address, integer size)

    // It is IMPLEMENTATION DEFINED whether the detection of memory aborts happens
    // before or after the check on the local Exclusives monitor. As a result a failure
    // of the local monitor can occur on some implementations even if the memory
    // access would give an memory abort.

    acctype = AccType_ATOMIC;
    iswrite = TRUE;

    aligned = AArch64.CheckAlignment(address, size, acctype, iswrite);

    passed = AArch64.IsExclusiveVA(address, ProcessorID(), size);
    if !passed then
        return FALSE;

    memaddrdesc = AArch64.TranslateAddress(address, acctype, iswrite, aligned, size);
    // Check for aborts or debug exceptions
    if IsFault(memaddrdesc) then
        AArch64.Abort(address, memaddrdesc.fault);

    passed = IsExclusiveLocal(memaddrdesc.paddress, ProcessorID(), size);
    ClearExclusiveLocal(ProcessorID());

    if passed then
        if memaddrdesc.memattrs.shareability != Shareability_NSH then
            passed = IsExclusiveGlobal(memaddrdesc.paddress, ProcessorID(), size);

    return passed;
```

## Library pseudocode for aarch64/functions/exclusive/AArch64.IsExclusiveVA

```
// An optional IMPLEMENTATION DEFINED test for an exclusive access to a virtual
// address region of size bytes starting at address.
//
// It is permitted (but not required) for this function to return FALSE and
// cause a store exclusive to fail if the virtual address region is not
// totally included within the region recorded by MarkExclusiveVA().
//
// It is always safe to return TRUE which will check the physical address only.
boolean AArch64.IsExclusiveVA(bits(64) address, integer processorid, integer size);
```

## Library pseudocode for aarch64/functions/exclusive/AArch64.MarkExclusiveVA

```
// Optionally record an exclusive access to the virtual address region of size bytes
// starting at address for processorid.
AArch64.MarkExclusiveVA(bits(64) address, integer processorid, integer size);
```

## Library pseudocode for aarch64/functions/exclusive/AArch64.SetExclusiveMonitors

```
// AArch64.SetExclusiveMonitors()
// =====
// Sets the Exclusives monitors for the current PE to record the addresses associated
// with the virtual address region of size bytes starting at address.

AArch64.SetExclusiveMonitors(bits(64) address, integer size)
    acctype = AccType\_ATOMIC;
    iswrite = FALSE;

    aligned = AArch64.CheckAlignment(address, size, acctype, iswrite);

    memaddrdesc = AArch64.TranslateAddress(address, acctype, iswrite, aligned, size);
    // Check for aborts or debug exceptions
    if IsFault(memaddrdesc) then
        return;

    if memaddrdesc.memattrs.shareability != Shareability\_NSH then
        MarkExclusiveGlobal(memaddrdesc.paddress, ProcessorID\(\), size);

    MarkExclusiveLocal(memaddrdesc.paddress, ProcessorID\(\), size);

    AArch64.MarkExclusiveVA(address, ProcessorID\(\), size);
```

## Library pseudocode for aarch64/functions/fusedrstep/FPRSqrtStepFused

```
// FPRSqrtStepFused()
// =====

bits(N) FPRSqrtStepFused(bits(N) op1, bits(N) op2)
    assert N IN {16, 32, 64};
    bits(N) result;
    FPCRTType fpcr = FPCR[];
    op1 = FPNeg(op1);
    boolean altfp = HaveAltFP() && fpcr.AH == '1';
    boolean fpexc = !altfp; // Generate no floating-point exceptions
    if altfp then fpcr.<FIZ,FZ> = '11'; // Flush denormal input and output to zero
    if altfp then fpcr.RMode = '00'; // Use RNE rounding mode

    (type1,sign1,value1) = FPUunpack(op1, fpcr, fpexc);
    (type2,sign2,value2) = FPUunpack(op2, fpcr, fpexc);
    (done,result) = FPProcessNaNs(type1, type2, op1, op2, fpcr, FALSE, fpexc);
    FPRounding rounding = FPRoundingMode(fpcr);

    if !done then
        inf1 = (type1 == FPTType\_Infinity);
        inf2 = (type2 == FPTType\_Infinity);
        zero1 = (type1 == FPTType\_Zero);
        zero2 = (type2 == FPTType\_Zero);

        if (inf1 && zero2) || (zero1 && inf2) then
            result = FPOnePointFive('0');
        elsif inf1 || inf2 then
            result = FPIInfinity(sign1 EOR sign2);
        else
            // Fully fused multiply-add and halve
            result_value = (3.0 + (value1 * value2)) / 2.0;
            if result_value == 0.0 then
                // Sign of exact zero result depends on rounding mode
                sign = if rounding == FPRounding\_NEGINF then '1' else '0';
                result = FPZero(sign);
            else
                result = FPRound(result_value, fpcr, rounding, fpexc);

    return result;
```

## Library pseudocode for aarch64/functions/fusedrstep/FPRecipStepFused

```
// FPRecipStepFused()
// =====

bits(N) FPRecipStepFused(bits(N) op1, bits(N) op2)
  assert N IN {16, 32, 64};
  bits(N) result;
  FPCRTType fpcr = FPCR[];
  op1 = FPNeg(op1);

  boolean altfp = HaveAltFP() && fpcr.AH == '1';
  boolean fpexc = !altfp; // Generate no floating-point exceptions
  if altfp then fpcr.<FIZ,FZ> = '11'; // Flush denormal input and output to zero
  if altfp then fpcr.RMode = '00'; // Use RNE rounding mode

  (type1,sign1,value1) = FPUnpack(op1, fpcr, fpexc);
  (type2,sign2,value2) = FPUnpack(op2, fpcr, fpexc);
  (done,result) = FPProcessNaNs(type1, type2, op1, op2, fpcr, FALSE, fpexc);
  FPRounding rounding = FPRoundingMode(fpcr);

  if !done then
    inf1 = (type1 == FPType\_Infinity);
    inf2 = (type2 == FPType\_Infinity);
    zero1 = (type1 == FPType\_Zero);
    zero2 = (type2 == FPType\_Zero);

    if (inf1 && zero2) || (zero1 && inf2) then
      result = FPTwo('0');
    elsif inf1 || inf2 then
      result = FPInfinity(sign1 EOR sign2);
    else
      // Fully fused multiply-add
      result_value = 2.0 + (value1 * value2);
      if result_value == 0.0 then
        // Sign of exact zero result depends on rounding mode
        sign = if rounding == FPRounding\_NEGINF then '1' else '0';
        result = FPZero(sign);
      else
        result = FPRound(result_value, fpcr, rounding, fpexc);

  return result;
```

## Library pseudocode for aarch64/functions/memory/AArch64.AccessIsTagChecked

```
// AArch64.AccessIsTagChecked()
// =====
// TRUE if a given access is tag-checked, FALSE otherwise.

boolean AArch64.AccessIsTagChecked(bits(64) vaddr, AccType acctype)
    if PSTATE.M<4> == '1' then return FALSE;

    if EffectiveTBI(vaddr, FALSE, PSTATE.EL) == '0' then
        return FALSE;

    if EffectiveTCMA(vaddr, PSTATE.EL) == '1' && (vaddr<59:55> == '00000' || vaddr<59:55> == '11111') then
        return FALSE;

    if !AArch64.AllocationTagAccessIsEnabled(acctype) then
        return FALSE;

    if acctype IN {AccType\_IFETCH, AccType\_TTW, AccType\_DC, AccType\_IC} then
        return FALSE;

    if acctype == AccType\_NV2REGISTER then
        return FALSE;

    if PSTATE.TC0 == '1' then
        return FALSE;

    if !IsTagCheckedInstruction() then
        return FALSE;

    return TRUE;
```

## Library pseudocode for aarch64/functions/memory/AArch64.AddressWithAllocationTag

```
// AArch64.AddressWithAllocationTag()
// =====
// Generate a 64-bit value containing a Logical Address Tag from a 64-bit
// virtual address and an Allocation Tag.
// If the extension is disabled, treats the Allocation Tag as '0000'.

bits(64) AArch64.AddressWithAllocationTag(bits(64) address, AccType acctype, bits(4) allocation_tag)
    bits(64) result = address;
    bits(4) tag;
    if AArch64.AllocationTagAccessIsEnabled(acctype) then
        tag = allocation_tag;
    else
        tag = '0000';
    result<59:56> = tag;
    return result;
```

## Library pseudocode for aarch64/functions/memory/AArch64.AllocationTagFromAddress

```
// AArch64.AllocationTagFromAddress()
// =====
// Generate an Allocation Tag from a 64-bit value containing a Logical Address Tag.

bits(4) AArch64.AllocationTagFromAddress(bits(64) tagged_address)
    return tagged_address<59:56>;
```

## Library pseudocode for aarch64/functions/memory/AArch64.CheckAlignment

```
// AArch64.CheckAlignment()
// =====

boolean AArch64.CheckAlignment(bits(64) address, integer alignment, AccType acctype,
                               boolean iswrite)

    aligned = (address == Align(address, alignment));
    atomic  = acctype IN { AccType\_ATOMIC, AccType\_ATOMICRW, AccType\_ORDEREDATOMIC,
                          AccType\_ORDEREDATOMICRW, AccType\_ATOMICLS64, AccType\_A32LSMD};
    ordered = acctype IN { AccType\_ORDERED, AccType\_ORDEREDRW, AccType\_LIMITEDORDERED, AccType\_ORDEREDATOMIC};
    vector  = acctype == AccType\_VEC;
    if SCTLR[][A] == '1' then check = TRUE;
    elsif HavelSE2Ext() then
        check = (UInt(address<0+:4>) + alignment > 16) && ((ordered && SCTLR[][nAA] == '0') || atomic);
    else check = atomic || ordered;

    if check && !aligned then
        secondstage = FALSE;
        AArch64.Abort(address, AlignmentFault(acctype, iswrite, secondstage));

    return aligned;
```

## Library pseudocode for aarch64/functions/memory/AArch64.CheckTag

```
// AArch64.CheckTag()
// =====
// Performs a Tag Check operation for a memory access and returns
// whether the check passed

boolean AArch64.CheckTag(AddressDescriptor memaddrdesc, bits(4) ptag, boolean write)
    if memaddrdesc.memattrs.tagged then
        return ptag == \_MemTag[memaddrdesc];
    else
        return TRUE;
```



```

// AArch64.MemSingle[] - non-assignment (read) form
// =====
// Perform an atomic, little-endian read of 'size' bytes.

bits(size*8) AArch64.MemSingle[bits(64) address, integer size, AccType acctype, boolean wasaligned]
    boolean ispair = FALSE;
    return AArch64.MemSingle[address, size, acctype, wasaligned, ispair];

// AArch64.MemSingle[] - non-assignment (read) form
// =====
// Perform an atomic, little-endian read of 'size' bytes.

bits(size*8) AArch64.MemSingle[bits(64) address, integer size, AccType acctype, boolean wasaligned, boolean ispair]
    assert size IN {1, 2, 4, 8, 16};
    if HaveLSE2Ext() then
        assert CheckAllInAlignedQuantity(address, size, 16);
    else
        assert address == Align(address, size);

    AddressDescriptor memaddrdesc;
    bits(size*8) value;
    iswrite = FALSE;

    memaddrdesc = AArch64.TranslateAddress(address, acctype, iswrite, wasaligned, size);
    // Check for aborts or debug exceptions
    if IsFault(memaddrdesc) then
        AArch64.Abort(address, memaddrdesc.fault);

    // Memory array access
    accdesc = CreateAccessDescriptor(acctype);
    if HaveMTE2Ext() then
        if AArch64.AccessIsTagChecked(ZeroExtend(address, 64), acctype) then
            bits(4) ptag = AArch64.PhysicalTag(ZeroExtend(address, 64));
            if !AArch64.CheckTag(memaddrdesc, ptag, iswrite) then
                AArch64.TagCheckFault(ZeroExtend(address, 64), acctype, iswrite);

    integer halfsize = size DIV 2;
    (atomic, splitpair) = CheckSingleAccessAttributes(address, memaddrdesc.memattrs, size, acctype, iswrite);
    if atomic then
        value = _Mem[memaddrdesc, size, accdesc, FALSE];
    elsif splitpair then
        assert ispair;
        value1 = _Mem[memaddrdesc, halfsize, accdesc, FALSE];
        memaddrdesc.paddress.address = memaddrdesc.paddress.address + halfsize<52-1:0>;
        value2 = _Mem[memaddrdesc, halfsize, accdesc, FALSE];

        value = value2<8*(size DIV 2)-1:0>;value1<8*(size DIV 2)-1:0>;
    else
        for i = 0 to size-1
            value<8*i+7:8*i> = _Mem[memaddrdesc, 1, accdesc, FALSE];
            memaddrdesc.paddress.address = memaddrdesc.paddress.address + 1<52-1:0>;

    return value;

// AArch64.MemSingle[] - assignment (write) form
// =====

AArch64.MemSingle[bits(64) address, integer size, AccType acctype, boolean wasaligned] = bits(size*8) value
    boolean ispair = FALSE;
    AArch64.MemSingle[address, size, acctype, wasaligned, ispair] = value;
    return;

// AArch64.MemSingle[] - assignment (write) form
// =====
// Perform an atomic, little-endian write of 'size' bytes.

AArch64.MemSingle[bits(64) address, integer size, AccType acctype, boolean wasaligned, boolean ispair] =
    assert size IN {1, 2, 4, 8, 16};
    if HaveLSE2Ext() then
        assert CheckAllInAlignedQuantity(address, size, 16);

```



```

else
    assert address == Align(address, size);

AddressDescriptor memaddrdesc;
iswrite = TRUE;

memaddrdesc = AArch64.TranslateAddress(address, acctype, iswrite, wasaligned, size);
// Check for aborts or debug exceptions
if IsFault(memaddrdesc) then
    AArch64.Abort(address, memaddrdesc.fault);

// Effect on exclusives
if memaddrdesc.memattrs.shareability != Shareability_NSH then
    ClearExclusiveByAddress(memaddrdesc.paddress, ProcessorID(), size);

// Memory array access
accdesc = CreateAccessDescriptor(acctype);
if HaveMTE2Ext() then
    if AArch64.AccessIsTagChecked(ZeroExtend(address, 64), acctype) then
        bits(4) ptag = AArch64.PhysicalTag(ZeroExtend(address, 64));
        if !AArch64.CheckTag(memaddrdesc, ptag, iswrite) then
            AArch64.TagCheckFault(ZeroExtend(address, 64), acctype, iswrite);

(atomic, splitpair) = CheckSingleAccessAttributes(address, memaddrdesc.memattrs, size, acctype, iswrite);
if atomic then
    _Mem[memaddrdesc, size, accdesc] = value;
elseif splitpair then
    assert ispair;
    integer halfsize = size DIV 2;
    bits(halfsize*8) val1 = value<(8*halfsize)-1:0>;
    bits(halfsize*8) val2 = value<(16*halfsize)-1:(8*halfsize)>;
    _Mem[memaddrdesc, halfsize, accdesc] = val1;
    memaddrdesc.paddress.address = memaddrdesc.paddress.address + halfsize<52-1:0>;
    _Mem[memaddrdesc, halfsize, accdesc] = val2;
else
    for i = 0 to size-1
        _Mem[memaddrdesc, 1, accdesc] = value<8*i+7:8*i>;
        memaddrdesc.paddress.address = memaddrdesc.paddress.address + 1<52-1:0>;
return;

```

## Library pseudocode for aarch64/functions/memory/AArch64.MemTag

```
// AArch64.MemTag[] - non-assignment (read) form
// =====
// Load an Allocation Tag from memory.

bits(4) AArch64.MemTag[bits(64) address, AccType acctype]
    assert acctype == AccType_NORMAL;
    AddressDescriptor memaddrdesc;
    bits(4) value;

    iswrite = FALSE;
    aligned = TRUE;
    memaddrdesc = AArch64.TranslateAddress(address, acctype, iswrite, aligned,
                                           TAG_GRANULE);
    // Check for aborts or debug exceptions
    if IsFault(memaddrdesc) then
        AArch64.Abort(address, memaddrdesc.fault);

    // Return the granule tag if tagging is enabled...
    if AArch64.AllocationTagAccessIsEnabled(acctype) && memaddrdesc.memattrs.tagged then
        return _MemTag[memaddrdesc];
    else
        // ...otherwise read tag as zero.
        return '0000';

// AArch64.MemTag[] - assignment (write) form
// =====
// Store an Allocation Tag to memory.

AArch64.MemTag[bits(64) address, AccType acctype] = bits(4) value
    assert acctype == AccType_NORMAL;
    AddressDescriptor memaddrdesc;
    iswrite = TRUE;

    // Stores of allocation tags must be aligned
    if address != Align(address, TAG_GRANULE) then
        boolean secondstage = FALSE;
        AArch64.Abort(address, AlignmentFault(acctype, iswrite, secondstage));

    aligned = TRUE;
    memaddrdesc = AArch64.TranslateAddress(address, acctype, iswrite, aligned,
                                           TAG_GRANULE);

    // It is CONSTRAINED UNPREDICTABLE if tags stored to memory locations marked as Device
    // generate an Alignment Fault or store the data to locations.
    if memaddrdesc.memattrs.memtype == MemType_Device then
        c = ConstrainUnpredictable(Unpredictable_DEVICETAGSTORE);
        assert c IN {Constraint_NONE, Constraint_FAULT};
        if c == Constraint_FAULT then
            boolean secondstage = FALSE;
            AArch64.Abort(address, AlignmentFault(acctype, iswrite, secondstage));

    // Check for aborts or debug exceptions
    if IsFault(memaddrdesc) then
        AArch64.Abort(address, memaddrdesc.fault);

    // Memory array access
    if AArch64.AllocationTagAccessIsEnabled(acctype) && memaddrdesc.memattrs.tagged then
        _MemTag[memaddrdesc] = value;
```

## Library pseudocode for aarch64/functions/memory/AArch64.PhysicalTag

```
// AArch64.PhysicalTag()
// =====
// Generate a Physical Tag from a Logical Tag in an address

bits(4) AArch64.PhysicalTag(bits(64) vaddr)
    return vaddr<59:56>;
```

## Library pseudocode for aarch64/functions/memory/AArch64.TranslateAddressForAtomicAccess

```
// AArch64.TranslateAddressForAtomicAccess()
// =====
// Performs an alignment check for atomic memory operations.
// Also translates 64-bit Virtual Address into Physical Address.

AddressDescriptor AArch64.TranslateAddressForAtomicAccess(bits(64) address, integer sizeinbits)
    boolean iswrite = FALSE;
    size = sizeinbits DIV 8;

    assert size IN {1, 2, 4, 8, 16};

    aligned = AArch64.CheckAlignment(address, size, AccType_ATOMICRW, iswrite);

    // MMU or MPU lookup
    memaddrdesc = AArch64.TranslateAddress(address, AccType_ATOMICRW, iswrite,
                                           aligned, size);

    // Check for aborts or debug exceptions
    if IsFault(memaddrdesc) then
        AArch64.Abort(address, memaddrdesc.fault);

    // Effect on exclusives
    if memaddrdesc.memattrs.shareability != Shareability_NSH then
        ClearExclusiveByAddress(memaddrdesc.paddress, ProcessorID(), size);

    if HaveMTE2Ext() && AArch64.AccessIsTagChecked(address, AccType_ATOMICRW) then
        bits(4) ptag = AArch64.PhysicalTag(address);
        if !AArch64.CheckTag(memaddrdesc, ptag, iswrite) then
            AArch64.TagCheckFault(address, AccType_ATOMICRW, iswrite);

    return memaddrdesc;
```

## Library pseudocode for aarch64/functions/memory/AddressSupportsLS64

```
// Returns TRUE if the 64-byte block following the given address supports the
// LD64B and ST64B instructions, and FALSE otherwise.
boolean AddressSupportsLS64(bits(64) address);
```

## Library pseudocode for aarch64/functions/memory/CheckAllInAlignedQuantity

```
// CheckAllInAlignedQuantity()
// =====
// Returns TRUE if all accessed bytes are within one aligned quantity, FALSE otherwise.

boolean CheckAllInAlignedQuantity(bits(64) address, integer size, integer alignment)
    assert(size <= alignment);
    return Align(address+size-1, alignment) == Align(address, alignment);
```

## Library pseudocode for aarch64/functions/memory/CheckSPAlignment

```
// CheckSPAlignment()
// =====
// Check correct stack pointer alignment for AArch64 state.

CheckSPAlignment()
    bits(64) sp = SP[];
    if PSTATE.EL == EL0 then
        stack_align_check = (SCTLR[].SA0 != '0');
    else
        stack_align_check = (SCTLR[].SA != '0');

    if stack_align_check && sp != Align(sp, 16) then
        AArch64.SPAlignmentFault();

    return;
```

## Library pseudocode for aarch64/functions/memory/CheckSingleAccessAttributes

```
// CheckSingleAccessAttributes()
// =====
//
// When FEAT_LSE2 is implemented, a MemSingle[] access needs to be further assessed once the memory
// attributes are determined.
// If it was aligned to access size or targets Normal Inner Write-Back, Outer Write-Back Cacheable
// memory then it is single copy atomic and there is no alignment fault.
// If not, for exclusives, atomics and non atomic acquire release instructions - it is CONSTRAINED UNPREDICTABLE
// if they generate an alignment fault. If they do not generate an alignment fault - they are
// single copy atomic.
// Otherwise it is IMPLEMENTATION DEFINED - if they are single copy atomic.
//
// The function returns (atomic, splitpair), where
//   atomic indicates if the access is single copy atomic.
//   splitpair indicates that a load/store pair is split into 2 single copy atomic accesses.
//   when atomic and splitpair are both FALSE - the access is not single copy atomic and may be treated
//   as byte accesses.

(boolean, boolean) CheckSingleAccessAttributes(bits(64) address, MemoryAttributes memattrs, integer size,
AccType acctype, boolean iswrite, boolean wasaligned, boolean ispair)
    isnormalwb = (memattrs.memtype == MemType\_Normal &&
        memattrs.inner.attrs == MemAttr\_WB &&
        memattrs.outer.attrs == MemAttr\_WB);

    atomic = TRUE;
    splitpair = FALSE;
    if isnormalwb then return (atomic, splitpair);

    accatomic = acctype IN { AccType\_ATOMIC, AccType\_ATOMICRW, AccType\_ORDEREDATOMIC,
        AccType\_ORDEREDATOMICRW, AccType\_ATOMICLS64, AccType\_A32LSMD };
    ordered = acctype IN { AccType\_ORDERED, AccType\_ORDEREDRW, AccType\_LIMITEDORDERED, AccType\_ORDEREDATOMIC };

    if !wasaligned && (accatomic || ordered) then
        atomic = ConstrainUnpredictableBool(Unpredictable\_MISALIGNEDATOMIC);
        if !atomic then
            secondstage = FALSE;
            AArch64.Abort(address, AlignmentFault(acctype, iswrite, secondstage));
        else
            return (atomic, splitpair);

    if ispair && wasaligned then
        // load / store pair requests that are aligned to each register access are split into 2 single copy atomic
        atomic = FALSE;
        splitpair = TRUE;
        return (atomic, splitpair);

    if wasaligned then
        return (atomic, splitpair);

    atomic = boolean IMPLEMENTATION_DEFINED "Misaligned accesses within 16 byte aligned memory but not No
    return (atomic, splitpair);
```

## Library pseudocode for aarch64/functions/memory/IsTagCheckedInstruction

```
// Returns True if the current instruction uses tag-checked memory access,
// False otherwise.
boolean IsTagCheckedInstruction();
```



```

// Mem[] - non-assignment (read) form
// =====
// Perform a read of 'size' bytes. The access byte order is reversed for a big-endian access.
// Instruction fetches would call AArch64.MemSingle directly.

bits(size*8) Mem(bits(64) address, integer size, AccType acctype]
    boolean ispair = FALSE;
    return Mem[address, size, acctype, ispair];

bits(size*8) Mem(bits(64) address, integer size, AccType acctype, boolean ispair]
    assert size IN {1, 2, 4, 8, 16};
    bits(size*8) value;
    boolean iswrite = FALSE;
    integer halfsize = size DIV 2;

    if ispair then
        // check alignment on size of element accessed, not overall access size
        aligned = AArch64.CheckAlignment(address, halfsize, acctype, iswrite);
    else
        aligned = AArch64.CheckAlignment(address, size, acctype, iswrite);
    if size != 16 || !(acctype IN {AccType_VEC, AccType_VECSTREAM}) then
        if !HaveLSE2Ext() then
            atomic = aligned;
        else
            atomic = CheckAllInAlignedQuantity(address, size, 16);
    elseif acctype IN {AccType_VEC, AccType_VECSTREAM} then
        // 128-bit SIMD&FP loads are treated as a pair of 64-bit single-copy atomic accesses
        // 64-bit aligned.
        atomic = address == Align(address, 8);
    else
        // 16-byte integer access
        atomic = address == Align(address, 16);

    if !atomic && ispair && address == Align(address, halfsize) then
        single_is_pair = FALSE;
        single_is_aligned = TRUE;
        value1 = AArch64.MemSingle[address, halfsize, acctype, single_is_aligned, single_is_pair];
        value2 = AArch64.MemSingle[address + halfsize, halfsize, acctype, single_is_aligned, single_is_pair];
        value = value2<8*(size DIV 2)-1:0>:value1<8*(size DIV 2)-1:0>;
    elseif atomic && ispair then
        value = AArch64.MemSingle[address, size, acctype, aligned, ispair];
    elseif !atomic then

        assert size > 1;
        value<7:0> = AArch64.MemSingle[address, 1, acctype, aligned];

        // For subsequent bytes it is CONSTRAINED UNPREDICTABLE whether an unaligned Device memory
        // access will generate an Alignment Fault, as to get this far means the first byte did
        // not, so we must be changing to a new translation page.
        if !aligned then
            c = ConstrainUnpredictable(Unpredictable_DEVPAGE2);
            assert c IN {Constraint_FAULT, Constraint_NONE};
            if c == Constraint_NONE then aligned = TRUE;

            for i = 1 to size-1
                value<8*i+7:8*i> = AArch64.MemSingle[address+i, 1, acctype, aligned];
        elseif size == 16 && acctype IN {AccType_VEC, AccType_VECSTREAM} then
            value<63:0> = AArch64.MemSingle[address, 8, acctype, aligned, ispair];
            value<127:64> = AArch64.MemSingle[address+8, 8, acctype, aligned, ispair];
        else
            value = AArch64.MemSingle[address, size, acctype, aligned, ispair];

        if BigEndian(acctype) then
            value = BigEndianReverse(value);

    return value;

// Mem[] - assignment (write) form
// =====
// Perform a write of 'size' bytes. The byte order is reversed for a big-endian access.

```

```

Mem[bits(64) address, integer size, AccType acctype] = bits(size*8) value
    boolean ispair = FALSE;
    Mem[address, size, acctype, ispair] = value;

Mem[bits(64) address, integer size, AccType acctype, boolean ispair] = bits(size*8) value
    boolean iswrite = TRUE;
    integer halfsize = size DIV 2;

    if BigEndian(acctype) then
        value = BigEndianReverse(value);

    if ispair then
        // check alignment on size of element accessed, not overall access size
        aligned = AArch64.CheckAlignment(address, halfsize, acctype, iswrite);
    else
        aligned = AArch64.CheckAlignment(address, size, acctype, iswrite);
    if ispair then
        atomic = CheckAllInAlignedQuantity(address, size, 16);
    elseif size != 16 || !(acctype IN {AccType\_VEC, AccType\_VECSTREAM}) then
        if !HaveLSE2Ext() then
            atomic = aligned;
        else
            atomic = CheckAllInAlignedQuantity(address, size, 16);
    elseif (acctype IN {AccType\_VEC, AccType\_VECSTREAM}) then
        // 128-bit SIMD&FP stores are treated as a pair of 64-bit single-copy atomic accesses
        // 64-bit aligned.
        atomic = address == Align(address, 8);
    else
        // 16-byte integer access
        atomic = address == Align(address, 16);

    if !atomic && ispair && address == Align(address, halfsize) then
        single_is_aligned = TRUE;
        bits(halfsize*8) val1 = value<(8*halfsize)-1:0>;
        bits(halfsize*8) val2 = value<(16*halfsize)-1:(8*halfsize)>;
        AArch64.MemSingle[address, halfsize, acctype, single_is_aligned, ispair] = val1;
        AArch64.MemSingle[address + halfsize, halfsize, acctype, single_is_aligned, ispair] = val2;
    elseif atomic && ispair then
        AArch64.MemSingle[address, size, acctype, aligned, ispair] = value;
    elseif !atomic then
        assert size > 1;
        AArch64.MemSingle[address, 1, acctype, aligned] = value<7:0>;

        // For subsequent bytes it is CONSTRAINED UNPREDICTABLE whether an unaligned Device memory
        // access will generate an Alignment Fault, as to get this far means the first byte did
        // not, so we must be changing to a new translation page.
        if !aligned then
            c = ConstrainUnpredictable(Unpredictable\_DEVPAGE2);
            assert c IN {Constraint\_FAULT, Constraint\_NONE};
            if c == Constraint\_NONE then aligned = TRUE;

        for i = 1 to size-1
            AArch64.MemSingle[address+i, 1, acctype, aligned] = value<8*i+7:8*i>;
    elseif size == 16 && acctype IN {AccType\_VEC, AccType\_VECSTREAM} then
        AArch64.MemSingle[address, 8, acctype, aligned, ispair] = value<63:0>;
        AArch64.MemSingle[address+8, 8, acctype, aligned, ispair] = value<127:64>;
    else
        AArch64.MemSingle[address, size, acctype, aligned, ispair] = value;
    return;

```

## Library pseudocode for aarch64/functions/memory/MemAtomic

```
// MemAtomic()
// =====
// Performs load and store memory operations for a given virtual address.

bits(size) MemAtomic(bits(64) address, MemAtomicOp op, bits(size) value, AccType ldacctype, AccType stacctype,
bits(size) newvalue;
memaddrdesc = AArch64.TranslateAddressForAtomicAccess(address, size);
ldaccdesc = CreateAccessDescriptor(ldacctype);
staccdesc = CreateAccessDescriptor(stacctype);

// All observers in the shareability domain observe the
// following load and store atomically.
oldvalue = _Mem[memaddrdesc, size DIV 8, ldaccdesc, FALSE];
if BigEndian(ldacctype) then
    oldvalue = BigEndianReverse(oldvalue);

case op of
    when MemAtomicOp\_ADD      newvalue = oldvalue + value;
    when MemAtomicOp\_BIC      newvalue = oldvalue AND NOT(value);
    when MemAtomicOp\_EOR      newvalue = oldvalue EOR value;
    when MemAtomicOp\_ORR      newvalue = oldvalue OR value;
    when MemAtomicOp\_SMAX     newvalue = if SInt(oldvalue) > SInt(value) then oldvalue else value;
    when MemAtomicOp\_SMIN     newvalue = if SInt(oldvalue) > SInt(value) then value else oldvalue;
    when MemAtomicOp\_UMAX     newvalue = if UInt(oldvalue) > UInt(value) then oldvalue else value;
    when MemAtomicOp\_UMIN     newvalue = if UInt(oldvalue) > UInt(value) then value else oldvalue;
    when MemAtomicOp\_SWP      newvalue = value;

if BigEndian(stacctype) then
    newvalue = BigEndianReverse(newvalue);

_Mem[memaddrdesc, size DIV 8, staccdesc] = newvalue;

// Load operations return the old (pre-operation) value
return oldvalue;
```

## Library pseudocode for aarch64/functions/memory/MemAtomicCompareAndSwap

```
// MemAtomicCompareAndSwap()
// =====
// Compares the value stored at the passed-in memory address against the passed-in expected
// value. If the comparison is successful, the value at the passed-in memory address is swapped
// with the passed-in new_value.

bits(size) MemAtomicCompareAndSwap(bits(64) address, bits(size) expectedvalue,
bits(size) newvalue, AccType ldacctype, AccType stacctype)
memaddrdesc = AArch64.TranslateAddressForAtomicAccess(address, size);
ldaccdesc = CreateAccessDescriptor(ldacctype);
staccdesc = CreateAccessDescriptor(stacctype);

// All observers in the shareability domain observe the
// following load and store atomically.
oldvalue = _Mem[memaddrdesc, size DIV 8, ldaccdesc, FALSE];
if BigEndian(ldacctype) then
    oldvalue = BigEndianReverse(oldvalue);

if oldvalue == expectedvalue then
    if BigEndian(stacctype) then
        newvalue = BigEndianReverse(newvalue);

    _Mem[memaddrdesc, size DIV 8, staccdesc] = newvalue;
return oldvalue;
```



## Library pseudocode for aarch64/functions/memory/MemLoad64B

```
// MemLoad64B()
// =====
// Performs an atomic 64-byte read from a given virtual address.

bits(512) MemLoad64B(bits(64) address, AccType acctype)
    bits(512) data;
    boolean iswrite = FALSE;
    constant integer size = 64;

    aligned = AArch64.CheckAlignment(address, size, acctype, iswrite);

    if !AddressSupportsLS64(address) then
        c = ConstrainUnpredictable(Unpredictable\_LS64UNSUPPORTED);
        assert c IN {Constraint\_LIMITED\_ATOMICITY, Constraint\_FAULT};

        if c == Constraint\_FAULT then
            // Generate a stage 1 Data Abort reported using the DFSC code of 110101.
            boolean secondstage = FALSE;
            boolean s2fslwalk = FALSE;
            fault = AArch64.ExclusiveFault(acctype, iswrite, secondstage, s2fslwalk);
            AArch64.Abort(address, fault);
        else
            // Accesses are not single-copy atomic above the byte level
            for i = 0 to 63
                data<7+8*i : 8*i> = AArch64.MemSingle[address+8*i, 1, acctype, aligned];
            return data;

    AddressDescriptor memaddrdesc;
    memaddrdesc = AArch64.TranslateAddress(address, acctype, iswrite, aligned, size);

    // Check for aborts or debug exceptions
    if IsFault(memaddrdesc) then
        AArch64.Abort(address, memaddrdesc.fault);

    // Effect on exclusives
    if memaddrdesc.memattr.shareability != Shareability\_NSH then
        ClearExclusiveByAddress(memaddrdesc.paddress, ProcessorID(), size);

    // Memory array access
    accdesc = CreateAccessDescriptor(acctype);

    if HaveMTE2Ext() then
        if AArch64.AccessIsTagChecked(ZeroExtend(address, 64), acctype) then
            bits(4) ptag = AArch64.PhysicalTag(ZeroExtend(address, 64));
            if !AArch64.CheckTag(memaddrdesc, ptag, iswrite) then
                AArch64.TagCheckFault(address, acctype, iswrite);

    data = _Mem[memaddrdesc, size, accdesc, iswrite];
    return data;
```

## Library pseudocode for aarch64/functions/memory/MemStore64B

```
// MemStore64B()
// =====
// Performs an atomic 64-byte store to a given virtual address. Function does
// not return the status of the store.

MemStore64B(bits(64) address, bits(512) value, AccType acctype)
    boolean iswrite = TRUE;
    constant integer size = 64;
    aligned = AArch64.CheckAlignment(address, size, acctype, iswrite);

    if !AddressSupportsLS64(address) then
        c = ConstrainUnpredictable(Unpredictable\_LS64UNSUPPORTED);
        assert c IN {Constraint\_LIMITED\_ATOMICITY, Constraint\_FAULT};

        if c == Constraint\_FAULT then
            // Generate a Data Abort reported using the DFSC code of 110101.
            boolean secondstage = FALSE;
            boolean s2fslwalk = FALSE;
            fault = AArch64.ExclusiveFault(acctype, iswrite, secondstage, s2fslwalk);
            AArch64.Abort(address, fault);
        else
            // Accesses are not single-copy atomic above the byte level.
            for i = 0 to 63
                AArch64.MemSingle[address+8*i, 1, acctype, aligned] = value<7+8*i : 8*i>;
    else
        -= MemStore64BWithRet(address, value, acctype); // Return status is ignored by ST64B
    return;
```

## Library pseudocode for aarch64/functions/memory/MemStore64BWithRet

```
// MemStore64BWithRet()
// =====
// Performs an atomic 64-byte store to a given virtual address returning
// the status value of the operation.

bits(64) MemStore64BWithRet(bits(64) address, bits(512) value, AccType acctype)
    AddressDescriptor memaddrdesc;
    boolean iswrite = TRUE;
    constant integer size = 64;

    aligned = AArch64.CheckAlignment(address, size, acctype, iswrite);
    memaddrdesc = AArch64.TranslateAddress(address, acctype, iswrite, aligned, size);

    // Check for aborts or debug exceptions
    if IsFault(memaddrdesc) then
        AArch64.Abort(address, memaddrdesc.fault);
        return ZeroExtend('1');

    // Effect on exclusives
    if memaddrdesc.memattrs.shareability != Shareability\_NSH then
        ClearExclusiveByAddress(memaddrdesc.paddress, ProcessorID(), 64);

    // Memory array access
    accdesc = CreateAccessDescriptor(acctype);

    if HaveMTE2Ext() then
        if AArch64.AccessIsTagChecked(ZeroExtend(address, 64), acctype) then
            bits(4) ptag = AArch64.PhysicalTag(ZeroExtend(address, 64));
            if !AArch64.CheckTag(memaddrdesc, ptag, iswrite) then
                AArch64.TagCheckFault(address, acctype, iswrite);
                return ZeroExtend('1');

    _Mem[memaddrdesc, size, accdesc] = value;
    status = MemStore64BWithRetStatus();
    return status;
```

## Library pseudocode for aarch64/functions/memory/MemStore64BWithRetStatus

```
// Generates the return status of memory write with ST64BV or ST64BV0
// instructions. The status indicates if the operation succeeded, failed,
// or was not supported at this memory location.
bits(64) MemStore64BWithRetStatus();
```

## Library pseudocode for aarch64/functions/memory/NVMem

```
// NVMem[] - non-assignment form
// =====
// This function is the load memory access for the transformed System register read access
// when Enhanced Nested Virtualisation is enabled with HCR_EL2.NV2 = 1.
// The address for the load memory access is calculated using
// the formula SignExtend(VNCR_EL2.BADDR : Offset<11:0>, 64) where,
// * VNCR_EL2.BADDR holds the base address of the memory location, and
// * Offset is the unique offset value defined architecturally for each System register that
// supports transformation of register access to memory access.

bits(64) NVMem[integer offset]
    assert offset > 0;
    bits(64) address = SignExtend(VNCR_EL2.BADDR:offset<11:0>, 64);
    return Mem[address, 8, AccType_NV2REGISTER];

// NVMem[] - assignment form
// =====
// This function is the store memory access for the transformed System register write access
// when Enhanced Nested Virtualisation is enabled with HCR_EL2.NV2 = 1.
// The address for the store memory access is calculated using
// the formula SignExtend(VNCR_EL2.BADDR : Offset<11:0>, 64) where,
// * VNCR_EL2.BADDR holds the base address of the memory location, and
// * Offset is the unique offset value defined architecturally for each System register that
// supports transformation of register access to memory access.

NVMem[integer offset] = bits(64) value
    assert offset > 0;
    bits(64) address = SignExtend(VNCR_EL2.BADDR:offset<11:0>, 64);
    Mem[address, 8, AccType_NV2REGISTER] = value;
    return;
```

## Library pseudocode for aarch64/functions/memory/SetTagCheckedInstruction

```
// Flag the current instruction as using/not using memory tag checking.
SetTagCheckedInstruction(boolean checked);
```

## Library pseudocode for aarch64/functions/memory/\_MemTag

```
// This _MemTag[] accessor is the hardware operation which perform a single-copy atomic,  
// Allocation Tag granule aligned, memory access from the tag in PA space.  
//  
// The function address the array using desc.paddress which supplies:  
// * A 52-bit physical address  
// * A single NS bit to select between Secure and Non-secure parts of the array.  
//  
// The accdesc descriptor describes the access type: normal, exclusive, ordered, streaming,  
// etc and other parameters required to access the physical memory or for setting syndrome  
// register in the event of an External abort.  
bits(4) _MemTag[AddressDescriptor desc, AccessDescriptor accdesc];  
  
// This _MemTag[] accessor is the hardware operation which perform a single-copy atomic,  
// Allocation Tag granule aligned, memory access to the tag in PA space.  
//  
// The functions address the array using desc.paddress which supplies:  
// * A 52-bit physical address  
// * A single NS bit to select between Secure and Non-secure parts of the array.  
//  
// The accdesc descriptor describes the access type: normal, exclusive, ordered, streaming,  
// etc and other parameters required to access the physical memory or for setting syndrome  
// register in the event of an External abort.  
_MemTag[AddressDescriptor desc, AccessDescriptor accdesc] = bits(4) value;
```



```

// AddPAC()
// =====
// Calculates the pointer authentication code for a 64-bit quantity and then
// inserts that into pointer authentication code field of that 64-bit quantity.

bits(64) AddPAC(bits(64) ptr, bits(64) modifier, bits(128) K, boolean data)
    bits(64) PAC;
    bits(64) result;
    bits(64) ext_ptr;
    bits(64) extfield;
    bit selbit;
    boolean tbi = EffectiveTBI(ptr, !data, PSTATE.EL) == '1';
    integer top_bit = if tbi then 55 else 63;

    // If tagged pointers are in use for a regime with two TTBRs, use bit<55> of
    // the pointer to select between upper and lower ranges, and preserve this.
    // This handles the awkward case where there is apparently no correct choice between
    // the upper and lower address range - ie an addr of 1xxxxxxx0... with TBI0=0 and TBI1=1
    // and 0xxxxxxx1 with TBI1=0 and TBI0=1:
    if PtrHasUpperAndLowerAddRanges() then
        assert S1TranslationRegime() IN {EL1, EL2};
        if S1TranslationRegime() == EL1 then
            // EL1 translation regime registers
            if data then
                if TCR_EL1.TBI1 == '1' || TCR_EL1.TBI0 == '1' then
                    selbit = ptr<55>;
                else
                    selbit = ptr<63>;
            else
                if ((TCR_EL1.TBI1 == '1' && TCR_EL1.TBID1 == '0') ||
                    (TCR_EL1.TBI0 == '1' && TCR_EL1.TBID0 == '0')) then
                    selbit = ptr<55>;
                else
                    selbit = ptr<63>;
        else
            // EL2 translation regime registers
            if data then
                if TCR_EL2.TBI1 == '1' || TCR_EL2.TBI0 == '1' then
                    selbit = ptr<55>;
                else
                    selbit = ptr<63>;
            else
                if ((TCR_EL2.TBI1 == '1' && TCR_EL2.TBID1 == '0') ||
                    (TCR_EL2.TBI0 == '1' && TCR_EL2.TBID0 == '0')) then
                    selbit = ptr<55>;
                else
                    selbit = ptr<63>;
    else selbit = if tbi then ptr<55> else ptr<63>;

    integer bottom_PAC_bit = CalculateBottomPACBit(selbit);

    // The pointer authentication code field takes all the available bits in between
    extfield = Replicate(selbit, 64);

    // Compute the pointer authentication code for a ptr with good extension bits
    if tbi then
        ext_ptr = ptr<63:56>:extfield<(56-bottom_PAC_bit)-1:0>:ptr<bottom_PAC_bit-1:0>;
    else
        ext_ptr = extfield<(64-bottom_PAC_bit)-1:0>:ptr<bottom_PAC_bit-1:0>;

    PAC = ComputePAC(ext_ptr, modifier, K<127:64>, K<63:0>);

    // Check if the ptr has good extension bits and corrupt the pointer authentication code if not
    if !IsZero(ptr<top_bit:bottom_PAC_bit>) && !IsOnes(ptr<top_bit:bottom_PAC_bit>) then
        if HaveEnhancedPAC() then
            PAC = 0x0000000000000000<63:0>;
        elseif !HaveEnhancedPAC2() then
            PAC<top_bit-1> = NOT(PAC<top_bit-1>);

    // preserve the determination between upper and lower address at bit<55> and insert PAC

```

```

if !HaveEnhancedPAC2() then
  if tbi then
    result = ptr<63:56>:selbit:PAC<54:bottom_PAC_bit>:ptr<bottom_PAC_bit-1:0>;
  else
    result = PAC<63:56>:selbit:PAC<54:bottom_PAC_bit>:ptr<bottom_PAC_bit-1:0>;
else
  if tbi then
    result = ptr<63:56>:selbit:(ptr<54:bottom_PAC_bit> EOR PAC<54:bottom_PAC_bit>):ptr<bottom_PAC_bit-1:0>;
  else
    result = (ptr<63:56> EOR PAC<63:56>):selbit:(ptr<54:bottom_PAC_bit> EOR
      PAC<54:bottom_PAC_bit>):ptr<bottom_PAC_bit-1:0>;
return result;

```

## Library pseudocode for aarch64/functions/pac/addpacda/AddPACDA

```

// AddPACDA()
// =====
// Returns a 64-bit value containing X, but replacing the pointer authentication code
// field bits with a pointer authentication code, where the pointer authentication
// code is derived using a cryptographic algorithm as a combination of X, Y and the
// APDAKey_EL1.

bits(64) AddPACDA(bits(64) X, bits(64) Y)
  boolean TrapEL2;
  boolean TrapEL3;
  bits(1) Enable;
  bits(128) APDAKey_EL1;

  APDAKey_EL1 = APDAKeyHi_EL1<63:0> : APDAKeyLo_EL1<63:0>;
  case PSTATE.EL of
    when EL0
      boolean IsEL1Regime = S1TranslationRegime() == EL1;
      Enable = if IsEL1Regime then SCTLRL_EL1.EnDA else SCTLRL_EL2.EnDA;
      TrapEL2 = (EL2Enabled() && HCR_EL2.API == '0' &&
        (HCR_EL2.TGE == '0' || HCR_EL2.E2H == '0'));
      TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
    when EL1
      Enable = SCTLRL_EL1.EnDA;
      TrapEL2 = EL2Enabled() && HCR_EL2.API == '0';
      TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
    when EL2
      Enable = SCTLRL_EL2.EnDA;
      TrapEL2 = FALSE;
      TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
    when EL3
      Enable = SCTLRL_EL3.EnDA;
      TrapEL2 = FALSE;
      TrapEL3 = FALSE;

  if Enable == '0' then return X;
  elsif TrapEL2 then TrapPACUse(EL2);
  elsif TrapEL3 then TrapPACUse(EL3);
  else return AddPAC(X, Y, APDAKey_EL1, TRUE);

```

## Library pseudocode for aarch64/functions/pac/addpacdb/AddPACDB

```
// AddPACDB()
// =====
// Returns a 64-bit value containing X, but replacing the pointer authentication code
// field bits with a pointer authentication code, where the pointer authentication
// code is derived using a cryptographic algorithm as a combination of X, Y and the
// APDBKey_EL1.

bits(64) AddPACDB(bits(64) X, bits(64) Y)
    boolean TrapEL2;
    boolean TrapEL3;
    bits(1) Enable;
    bits(128) APDBKey_EL1;

    APDBKey_EL1 = APDBKeyHi_EL1<63:0> : APDBKeyLo_EL1<63:0>;
    case PSTATE.EL of
        when EL0
            boolean IsEL1Regime = S1TranslationRegime\(\) == EL1;
            Enable = if IsEL1Regime then SCTLRL_EL1.EnDB else SCTLRL_EL2.EnDB;
            TrapEL2 = (EL2Enabled\(\) && HCR_EL2.API == '0' &&
                (HCR_EL2.TGE == '0' || HCR_EL2.E2H == '0'));
            TrapEL3 = HaveEL\(EL3\) && SCR_EL3.API == '0';
        when EL1
            Enable = SCTLRL_EL1.EnDB;
            TrapEL2 = EL2Enabled\(\) && HCR_EL2.API == '0';
            TrapEL3 = HaveEL\(EL3\) && SCR_EL3.API == '0';
        when EL2
            Enable = SCTLRL_EL2.EnDB;
            TrapEL2 = FALSE;
            TrapEL3 = HaveEL\(EL3\) && SCR_EL3.API == '0';
        when EL3
            Enable = SCTLRL_EL3.EnDB;
            TrapEL2 = FALSE;
            TrapEL3 = FALSE;

    if Enable == '0' then return X;
    elsif TrapEL2 then TrapPACUse\(EL2\);
    elsif TrapEL3 then TrapPACUse\(EL3\);
    else return AddPAC\(X, Y, APDBKey\_EL1, TRUE\);
```



## Library pseudocode for aarch64/functions/pac/addpacga/AddPACGA

```
// AddPACGA()
// =====
// Returns a 64-bit value where the lower 32 bits are 0, and the upper 32 bits contain
// a 32-bit pointer authentication code which is derived using a cryptographic
// algorithm as a combination of X, Y and the APGAKey_EL1.

bits(64) AddPACGA(bits(64) X, bits(64) Y)
    boolean TrapEL2;
    boolean TrapEL3;
    bits(128) APGAKey_EL1;

    APGAKey_EL1 = APGAKeyHi_EL1<63:0> : APGAKeyLo_EL1<63:0>;
    case PSTATE.EL of
        when EL0
            TrapEL2 = (EL2Enabled() && HCR_EL2.API == '0' &&
                        (HCR_EL2.TGE == '0' || HCR_EL2.E2H == '0'));
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL1
            TrapEL2 = EL2Enabled() && HCR_EL2.API == '0';
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL2
            TrapEL2 = FALSE;
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL3
            TrapEL2 = FALSE;
            TrapEL3 = FALSE;

    if TrapEL2 then TrapPACUse(EL2);
    elsif TrapEL3 then TrapPACUse(EL3);
    else return ComputePAC(X, Y, APGAKey_EL1<127:64>, APGAKey_EL1<63:0><63:32>:Zeros(32));
```

## Library pseudocode for aarch64/functions/pac/addpacia/AddPACIA

```
// AddPACIA()
// =====
// Returns a 64-bit value containing X, but replacing the pointer authentication code
// field bits with a pointer authentication code, where the pointer authentication
// code is derived using a cryptographic algorithm as a combination of X, Y, and the
// APIAKey_EL1.

bits(64) AddPACIA(bits(64) X, bits(64) Y)
    boolean TrapEL2;
    boolean TrapEL3;
    bits(1) Enable;
    bits(128) APIAKey_EL1;

    APIAKey_EL1 = APIAKeyHi_EL1<63:0>:APIAKeyLo_EL1<63:0>;
    case PSTATE.EL of
        when EL0
            boolean IsEL1Regime = S1TranslationRegime() == EL1;
            Enable = if IsEL1Regime then SCTLRL_EL1.EnIA else SCTLRL_EL2.EnIA;
            TrapEL2 = (EL2Enabled() && HCR_EL2.API == '0' &&
                (HCR_EL2.TGE == '0' || HCR_EL2.E2H == '0'));
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL1
            Enable = SCTLRL_EL1.EnIA;
            TrapEL2 = EL2Enabled() && HCR_EL2.API == '0';
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL2
            Enable = SCTLRL_EL2.EnIA;
            TrapEL2 = FALSE;
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL3
            Enable = SCTLRL_EL3.EnIA;
            TrapEL2 = FALSE;
            TrapEL3 = FALSE;

    if Enable == '0' then return X;
    elsif TrapEL2 then TrapPACUse(EL2);
    elsif TrapEL3 then TrapPACUse(EL3);
    else return AddPAC(X, Y, APIAKey_EL1, FALSE);
```

## Library pseudocode for aarch64/functions/pac/addpacib/AddPACIB

```
// AddPACIB()
// =====
// Returns a 64-bit value containing X, but replacing the pointer authentication code
// field bits with a pointer authentication code, where the pointer authentication
// code is derived using a cryptographic algorithm as a combination of X, Y and the
// APIBKey_EL1.

bits(64) AddPACIB(bits(64) X, bits(64) Y)
    boolean TrapEL2;
    boolean TrapEL3;
    bits(1) Enable;
    bits(128) APIBKey_EL1;

    APIBKey_EL1 = APIBKeyHi_EL1<63:0> : APIBKeyLo_EL1<63:0>;
    case PSTATE.EL of
        when EL0
            boolean IsEL1Regime = S1TranslationRegime() == EL1;
            Enable = if IsEL1Regime then SCTL_EL1.EnIB else SCTL_EL2.EnIB;
            TrapEL2 = (EL2Enabled() && HCR_EL2.API == '0' &&
                (HCR_EL2.TGE == '0' || HCR_EL2.E2H == '0'));
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL1
            Enable = SCTL_EL1.EnIB;
            TrapEL2 = EL2Enabled() && HCR_EL2.API == '0';
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL2
            Enable = SCTL_EL2.EnIB;
            TrapEL2 = FALSE;
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL3
            Enable = SCTL_EL3.EnIB;
            TrapEL2 = FALSE;
            TrapEL3 = FALSE;

    if Enable == '0' then return X;
    elsif TrapEL2 then TrapPACUse(EL2);
    elsif TrapEL3 then TrapPACUse(EL3);
    else return AddPAC(X, Y, APIBKey_EL1, FALSE);
```

## Library pseudocode for aarch64/functions/pac/auth/AArch64.PACFailException

```
// AArch64.PACFailException()
// =====
// Generates a PAC Fail Exception

AArch64.PACFailException(bits(2) syndrome)
    route_to_el2 = PSTATE.EL == EL0 && EL2Enabled() && HCR_EL2.TGE == '1';
    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x0;

    exception = ExceptionSyndrome(Exception_PACFail);
    exception.syndrome<1:0> = syndrome;
    exception.syndrome<24:2> = Zeros(); // RES0

    if UInt(PSTATE.EL) > UInt(EL0) then
        AArch64.TakeException(PSTATE.EL, exception, preferred_exception_return, vect_offset);
    elsif route_to_el2 then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/functions/pac/auth/Auth

```
// Auth()
// =====
// Restores the upper bits of the address to be all zeros or all ones (based on the
// value of bit[55]) and computes and checks the pointer authentication code. If the
// check passes, then the restored address is returned. If the check fails, the
// second-top and third-top bits of the extension bits in the pointer authentication code
// field are corrupted to ensure that accessing the address will give a translation fault.

bits(64) Auth(bits(64) ptr, bits(64) modifier, bits(128) K, boolean data, bit key_number, boolean is_combined)
    bits(64) PAC;
    bits(64) result;
    bits(64) original_ptr;
    bits(2) error_code;
    bits(64) extfield;

    // Reconstruct the extension field used of adding the PAC to the pointer
    boolean tbi = EffectiveTBI(ptr, !data, PSTATE.EL) == '1';
    integer bottom_PAC_bit = CalculateBottomPACBit(ptr<55>);
    extfield = Replicate(ptr<55>, 64);

    if tbi then
        original_ptr = ptr<63:56>:extfield<56-bottom_PAC_bit-1:0>:ptr<bottom_PAC_bit-1:0>;
    else
        original_ptr = extfield<64-bottom_PAC_bit-1:0>:ptr<bottom_PAC_bit-1:0>;

    PAC = ComputePAC(original_ptr, modifier, K<127:64>, K<63:0>);
    // Check pointer authentication code
    if tbi then
        if !HaveEnhancedPAC2() then
            if PAC<54:bottom_PAC_bit> == ptr<54:bottom_PAC_bit> then
                result = original_ptr;
            else
                error_code = key_number:NOT(key_number);
                result = original_ptr<63:55>:error_code:original_ptr<52:0>;
        else
            result = ptr;
            result<54:bottom_PAC_bit> = result<54:bottom_PAC_bit> EOR PAC<54:bottom_PAC_bit>;
            if HaveFPACCombined() || (HaveFPAC() && !is_combined) then
                if result<54:bottom_PAC_bit> != Replicate(result<55>, (55-bottom_PAC_bit)) then
                    error_code = (if data then '1' else '0'):key_number;
                    AArch64.PACFailException(error_code);
            else
                if !HaveEnhancedPAC2() then
                    if PAC<54:bottom_PAC_bit> == ptr<54:bottom_PAC_bit> && PAC<63:56> == ptr<63:56> then
                        result = original_ptr;
                    else
                        error_code = key_number:NOT(key_number);
                        result = original_ptr<63>:error_code:original_ptr<60:0>;
                else
                    result = ptr;
                    result<54:bottom_PAC_bit> = result<54:bottom_PAC_bit> EOR PAC<54:bottom_PAC_bit>;
                    result<63:56> = result<63:56> EOR PAC<63:56>;
                    if HaveFPACCombined() || (HaveFPAC() && !is_combined) then
                        if result<63:bottom_PAC_bit> != Replicate(result<55>, (64-bottom_PAC_bit)) then
                            error_code = (if data then '1' else '0'):key_number;
                            AArch64.PACFailException(error_code);
    return result;
```

## Library pseudocode for aarch64/functions/pac/authda/AuthDA

```
// AuthDA()
// =====
// Returns a 64-bit value containing X, but replacing the pointer authentication code
// field bits with the extension of the address bits. The instruction checks a pointer
// authentication code in the pointer authentication code field bits of X, using the same
// algorithm and key as AddPACDA().

bits(64) AuthDA(bits(64) X, bits(64) Y, boolean is_combined)
    boolean TrapEL2;
    boolean TrapEL3;
    bits(1) Enable;
    bits(128) APDAKey_EL1;

    APDAKey_EL1 = APDAKeyHi_EL1<63:0> : APDAKeyLo_EL1<63:0>;
    case PSTATE.EL of
        when EL0
            boolean IsEL1Regime = S1TranslationRegime() == EL1;
            Enable = if IsEL1Regime then SCTLRL_EL1.EnDA else SCTLRL_EL2.EnDA;
            TrapEL2 = (EL2Enabled() && HCR_EL2.API == '0' &&
                (HCR_EL2.TGE == '0' || HCR_EL2.E2H == '0'));
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL1
            Enable = SCTLRL_EL1.EnDA;
            TrapEL2 = EL2Enabled() && HCR_EL2.API == '0';
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL2
            Enable = SCTLRL_EL2.EnDA;
            TrapEL2 = FALSE;
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL3
            Enable = SCTLRL_EL3.EnDA;
            TrapEL2 = FALSE;
            TrapEL3 = FALSE;

    if Enable == '0' then return X;
    elsif TrapEL2 then TrapPACUse(EL2);
    elsif TrapEL3 then TrapPACUse(EL3);
    else return Auth(X, Y, APDAKey_EL1, TRUE, '0', is_combined);
```

## Library pseudocode for aarch64/functions/pac/authdb/AuthDB

```
// AuthDB()
// =====
// Returns a 64-bit value containing X, but replacing the pointer authentication code
// field bits with the extension of the address bits. The instruction checks a
// pointer authentication code in the pointer authentication code field bits of X, using
// the same algorithm and key as AddPACDB().

bits(64) AuthDB(bits(64) X, bits(64) Y, boolean is_combined)
    boolean TrapEL2;
    boolean TrapEL3;
    bits(1) Enable;
    bits(128) APDBKey_EL1;

    APDBKey_EL1 = APDBKeyHi_EL1<63:0> : APDBKeyLo_EL1<63:0>;
    case PSTATE.EL of
        when EL0
            boolean IsEL1Regime = S1TranslationRegime() == EL1;
            Enable = if IsEL1Regime then SCTLRL_EL1.EnDB else SCTLRL_EL2.EnDB;
            TrapEL2 = (EL2Enabled() && HCR_EL2.API == '0' &&
                (HCR_EL2.TGE == '0' || HCR_EL2.E2H == '0'));
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL1
            Enable = SCTLRL_EL1.EnDB;
            TrapEL2 = EL2Enabled() && HCR_EL2.API == '0';
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL2
            Enable = SCTLRL_EL2.EnDB;
            TrapEL2 = FALSE;
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL3
            Enable = SCTLRL_EL3.EnDB;
            TrapEL2 = FALSE;
            TrapEL3 = FALSE;

    if Enable == '0' then return X;
    elsif TrapEL2 then TrapPACUse(EL2);
    elsif TrapEL3 then TrapPACUse(EL3);
    else return Auth(X, Y, APDBKey_EL1, TRUE, '1', is_combined);
```

## Library pseudocode for aarch64/functions/pac/authia/AuthIA

```
// AuthIA()
// =====
// Returns a 64-bit value containing X, but replacing the pointer authentication code
// field bits with the extension of the address bits. The instruction checks a pointer
// authentication code in the pointer authentication code field bits of X, using the same
// algorithm and key as AddPACIA().

bits(64) AuthIA(bits(64) X, bits(64) Y, boolean is_combined)
    boolean TrapEL2;
    boolean TrapEL3;
    bits(1) Enable;
    bits(128) APIAKey_EL1;

    APIAKey_EL1 = APIAKeyHi_EL1<63:0> : APIAKeyLo_EL1<63:0>;
    case PSTATE.EL of
        when EL0
            boolean IsEL1Regime = S1TranslationRegime() == EL1;
            Enable = if IsEL1Regime then SCTLRL_EL1.EnIA else SCTLRL_EL2.EnIA;
            TrapEL2 = (EL2Enabled() && HCR_EL2.API == '0' &&
                (HCR_EL2.TGE == '0' || HCR_EL2.E2H == '0'));
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL1
            Enable = SCTLRL_EL1.EnIA;
            TrapEL2 = EL2Enabled() && HCR_EL2.API == '0';
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL2
            Enable = SCTLRL_EL2.EnIA;
            TrapEL2 = FALSE;
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL3
            Enable = SCTLRL_EL3.EnIA;
            TrapEL2 = FALSE;
            TrapEL3 = FALSE;

    if Enable == '0' then return X;
    elsif TrapEL2 then TrapPACUse(EL2);
    elsif TrapEL3 then TrapPACUse(EL3);
    else return Auth(X, Y, APIAKey_EL1, FALSE, '0', is_combined);
```

## Library pseudocode for aarch64/functions/pac/authib/AuthIB

```
// AuthIB()
// =====
// Returns a 64-bit value containing X, but replacing the pointer authentication code
// field bits with the extension of the address bits. The instruction checks a pointer
// authentication code in the pointer authentication code field bits of X, using the same
// algorithm and key as AddPACIB().

bits(64) AuthIB(bits(64) X, bits(64) Y, boolean is_combined)
    boolean TrapEL2;
    boolean TrapEL3;
    bits(1) Enable;
    bits(128) APIBKey_EL1;

    APIBKey_EL1 = APIBKeyHi_EL1<63:0> : APIBKeyLo_EL1<63:0>;
    case PSTATE.EL of
        when EL0
            boolean IsEL1Regime = S1TranslationRegime() == EL1;
            Enable = if IsEL1Regime then SCTLRL_EL1.EnIB else SCTLRL_EL2.EnIB;
            TrapEL2 = (EL2Enabled() && HCR_EL2.API == '0' &&
                (HCR_EL2.TGE == '0' || HCR_EL2.E2H == '0'));
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL1
            Enable = SCTLRL_EL1.EnIB;
            TrapEL2 = EL2Enabled() && HCR_EL2.API == '0';
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL2
            Enable = SCTLRL_EL2.EnIB;
            TrapEL2 = FALSE;
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL3
            Enable = SCTLRL_EL3.EnIB;
            TrapEL2 = FALSE;
            TrapEL3 = FALSE;

    if Enable == '0' then return X;
    elsif TrapEL2 then TrapPACUse(EL2);
    elsif TrapEL3 then TrapPACUse(EL3);
    else return Auth(X, Y, APIBKey_EL1, FALSE, '1', is_combined);
```



## Library pseudocode for aarch64/functions/pac/calcbottompacbit/CalculateBottomPACBit

```
// CalculateBottomPACBit()
// =====

integer CalculateBottomPACBit(bit top_bit)
    integer tsz_field;

    if PtrHasUpperAndLowerAddRanges() then
        assert S1TranslationRegime() IN {EL1, EL2};
        if S1TranslationRegime() == EL1 then
            // EL1 translation regime registers
            tsz_field = if top_bit == '1' then UInt(TCR_EL1.T1SZ) else UInt(TCR_EL1.T0SZ);
            using64k = if top_bit == '1' then TCR_EL1.TG1 == '11' else TCR_EL1.TG0 == '01';
        else
            // EL2 translation regime registers
            assert HaveEL(EL2);
            tsz_field = if top_bit == '1' then UInt(TCR_EL2.T1SZ) else UInt(TCR_EL2.T0SZ);
            using64k = if top_bit == '1' then TCR_EL2.TG1 == '11' else TCR_EL2.TG0 == '01';
    else
        tsz_field = if PSTATE.EL == EL2 then UInt(TCR_EL2.T0SZ) else UInt(TCR_EL3.T0SZ);
        using64k = if PSTATE.EL == EL2 then TCR_EL2.TG0 == '01' else TCR_EL3.TG0 == '01';

    max_limit_tsz_field = (if !HaveSmallTranslationTableExt() then 39 else if using64k then 47 else 48);
    if tsz_field > max_limit_tsz_field then
        // TCR_ELx.TySZ is out of range
        c = ConstrainUnpredictable(Unpredictable_RESTnSZ);
        assert c IN {Constraint_FORCE, Constraint_NONE};
        if c == Constraint_FORCE then tsz_field = max_limit_tsz_field;
    tszmin = if using64k && AArch64.VAMax() == 52 then 12 else 16;
    if tsz_field < tszmin then
        c = ConstrainUnpredictable(Unpredictable_RESTnSZ);
        assert c IN {Constraint_FORCE, Constraint_NONE};
        if c == Constraint_FORCE then tsz_field = tszmin;
    return (64-tsz_field);
```

## Library pseudocode for aarch64/functions/pac/computepac/ComputePAC

```
// ComputePAC()
// =====

bits(64) ComputePAC(bits(64) data, bits(64) modifier, bits(64) key0, bits(64) key1)
    bits(64) workingval;
    bits(64) runningmod;
    bits(64) roundkey;
    bits(64) modk0;
    constant bits(64) Alpha = 0xC0AC29B7C97C50DD<63:0>;

    RC[0] = 0x0000000000000000<63:0>;
    RC[1] = 0x13198A2E03707344<63:0>;
    RC[2] = 0xA4093822299F31D0<63:0>;
    RC[3] = 0x082EFA98EC4E6C89<63:0>;
    RC[4] = 0x452821E638D01377<63:0>;

    modk0 = key0<0>:key0<63:2>:(key0<63> EOR key0<1>);
    runningmod = modifier;
    workingval = data EOR key0;
    for i = 0 to 4
        roundkey = key1 EOR runningmod;
        workingval = workingval EOR roundkey;
        workingval = workingval EOR RC[i];
        if i > 0 then
            workingval = PACCellShuffle(workingval);
            workingval = PACMult(workingval);
            workingval = PACSub(workingval);
            runningmod = TweakShuffle(runningmod<63:0>);
        roundkey = modk0 EOR runningmod;
        workingval = workingval EOR roundkey;
        workingval = PACCellShuffle(workingval);
        workingval = PACMult(workingval);
        workingval = PACSub(workingval);
        workingval = PACCellShuffle(workingval);
        workingval = PACMult(workingval);
        workingval = key1 EOR workingval;
        workingval = PACCellInvShuffle(workingval);
        workingval = PACInvSub(workingval);
        workingval = PACMult(workingval);
        workingval = PACCellInvShuffle(workingval);
        workingval = workingval EOR key0;
        workingval = workingval EOR runningmod;
    for i = 0 to 4
        workingval = PACInvSub(workingval);
        if i < 4 then
            workingval = PACMult(workingval);
            workingval = PACCellInvShuffle(workingval);
            runningmod = TweakInvShuffle(runningmod<63:0>);
            roundkey = key1 EOR runningmod;
            workingval = workingval EOR RC[4-i];
            workingval = workingval EOR roundkey;
            workingval = workingval EOR Alpha;
    workingval = workingval EOR modk0;

    return workingval;
```

## Library pseudocode for aarch64/functions/pac/computepac/PACCellInvShuffle

```
// PACCellInvShuffle()
// =====

bits(64) PACCellInvShuffle(bits(64) indata)
    bits(64) outdata;
    outdata<3:0> = indata<15:12>;
    outdata<7:4> = indata<27:24>;
    outdata<11:8> = indata<51:48>;
    outdata<15:12> = indata<39:36>;
    outdata<19:16> = indata<59:56>;
    outdata<23:20> = indata<47:44>;
    outdata<27:24> = indata<7:4>;
    outdata<31:28> = indata<19:16>;
    outdata<35:32> = indata<35:32>;
    outdata<39:36> = indata<55:52>;
    outdata<43:40> = indata<31:28>;
    outdata<47:44> = indata<11:8>;
    outdata<51:48> = indata<23:20>;
    outdata<55:52> = indata<3:0>;
    outdata<59:56> = indata<43:40>;
    outdata<63:60> = indata<63:60>;
    return outdata;
```

## Library pseudocode for aarch64/functions/pac/computepac/PACCellShuffle

```
// PACCellShuffle()
// =====

bits(64) PACCellShuffle(bits(64) indata)
    bits(64) outdata;
    outdata<3:0> = indata<55:52>;
    outdata<7:4> = indata<27:24>;
    outdata<11:8> = indata<47:44>;
    outdata<15:12> = indata<3:0>;
    outdata<19:16> = indata<31:28>;
    outdata<23:20> = indata<51:48>;
    outdata<27:24> = indata<7:4>;
    outdata<31:28> = indata<43:40>;
    outdata<35:32> = indata<35:32>;
    outdata<39:36> = indata<15:12>;
    outdata<43:40> = indata<59:56>;
    outdata<47:44> = indata<23:20>;
    outdata<51:48> = indata<11:8>;
    outdata<55:52> = indata<39:36>;
    outdata<59:56> = indata<19:16>;
    outdata<63:60> = indata<63:60>;
    return outdata;
```

## Library pseudocode for aarch64/functions/pac/computepac/PACInvSub

```
// PACInvSub()
// =====

bits(64) PACInvSub(bits(64) Tinput)
// This is a 4-bit substitution from the PRINCE-family cipher
bits(64) Toutput;
for i = 0 to 15
    case Tinput<4*i+3:4*i> of
        when '0000' Toutput<4*i+3:4*i> = '0101';
        when '0001' Toutput<4*i+3:4*i> = '1110';
        when '0010' Toutput<4*i+3:4*i> = '1101';
        when '0011' Toutput<4*i+3:4*i> = '1000';
        when '0100' Toutput<4*i+3:4*i> = '1010';
        when '0101' Toutput<4*i+3:4*i> = '1011';
        when '0110' Toutput<4*i+3:4*i> = '0001';
        when '0111' Toutput<4*i+3:4*i> = '1001';
        when '1000' Toutput<4*i+3:4*i> = '0010';
        when '1001' Toutput<4*i+3:4*i> = '0110';
        when '1010' Toutput<4*i+3:4*i> = '1111';
        when '1011' Toutput<4*i+3:4*i> = '0000';
        when '1100' Toutput<4*i+3:4*i> = '0100';
        when '1101' Toutput<4*i+3:4*i> = '1100';
        when '1110' Toutput<4*i+3:4*i> = '0111';
        when '1111' Toutput<4*i+3:4*i> = '0011';
return Toutput;
```

## Library pseudocode for aarch64/functions/pac/computepac/PACMult

```
// PACMult()
// =====

bits(64) PACMult(bits(64) Sinput)
bits(4) t0;
bits(4) t1;
bits(4) t2;
bits(4) t3;
bits(64) Soutput;

for i = 0 to 3
    t0<3:0> = RotCell(Sinput<4*(i+8)+3:4*(i+8)>, 1) EOR RotCell(Sinput<4*(i+4)+3:4*(i+4)>, 2);
    t0<3:0> = t0<3:0> EOR RotCell(Sinput<4*(i)+3:4*(i)>, 1);
    t1<3:0> = RotCell(Sinput<4*(i+12)+3:4*(i+12)>, 1) EOR RotCell(Sinput<4*(i+4)+3:4*(i+4)>, 1);
    t1<3:0> = t1<3:0> EOR RotCell(Sinput<4*(i)+3:4*(i)>, 2);
    t2<3:0> = RotCell(Sinput<4*(i+12)+3:4*(i+12)>, 2) EOR RotCell(Sinput<4*(i+8)+3:4*(i+8)>, 1);
    t2<3:0> = t2<3:0> EOR RotCell(Sinput<4*(i)+3:4*(i)>, 1);
    t3<3:0> = RotCell(Sinput<4*(i+12)+3:4*(i+12)>, 1) EOR RotCell(Sinput<4*(i+8)+3:4*(i+8)>, 2);
    t3<3:0> = t3<3:0> EOR RotCell(Sinput<4*(i+4)+3:4*(i+4)>, 1);
    Soutput<4*i+3:4*i> = t3<3:0>;
    Soutput<4*(i+4)+3:4*(i+4)> = t2<3:0>;
    Soutput<4*(i+8)+3:4*(i+8)> = t1<3:0>;
    Soutput<4*(i+12)+3:4*(i+12)> = t0<3:0>;
return Soutput;
```

### Library pseudocode for aarch64/functions/pac/computepac/PACSub

```
// PACSub()
// =====

bits(64) PACSub(bits(64) Tinput)
// This is a 4-bit substitution from the PRINCE-family cipher
bits(64) Toutput;
for i = 0 to 15
    case Tinput<4*i+3:4*i> of
        when '0000' Toutput<4*i+3:4*i> = '1011';
        when '0001' Toutput<4*i+3:4*i> = '0110';
        when '0010' Toutput<4*i+3:4*i> = '1000';
        when '0011' Toutput<4*i+3:4*i> = '1111';
        when '0100' Toutput<4*i+3:4*i> = '1100';
        when '0101' Toutput<4*i+3:4*i> = '0000';
        when '0110' Toutput<4*i+3:4*i> = '1001';
        when '0111' Toutput<4*i+3:4*i> = '1110';
        when '1000' Toutput<4*i+3:4*i> = '0011';
        when '1001' Toutput<4*i+3:4*i> = '0111';
        when '1010' Toutput<4*i+3:4*i> = '0100';
        when '1011' Toutput<4*i+3:4*i> = '0101';
        when '1100' Toutput<4*i+3:4*i> = '1101';
        when '1101' Toutput<4*i+3:4*i> = '0010';
        when '1110' Toutput<4*i+3:4*i> = '0001';
        when '1111' Toutput<4*i+3:4*i> = '1010';
return Toutput;
```

### Library pseudocode for aarch64/functions/pac/computepac/RotCell

```
// RotCell()
// =====

bits(4) RotCell(bits(4) incell, integer amount)
    bits(8) tmp;
    bits(4) outcell;

    // assert amount>3 || amount<1;
    tmp<7:0> = incell<3:0>:incell<3:0>;
    outcell = tmp<7-amount:4-amount>;
    return outcell;
```

### Library pseudocode for aarch64/functions/pac/computepac/TweakCellInvRot

```
// TweakCellInvRot()
// =====

bits(4) TweakCellInvRot(bits(4) incell)
    bits(4) outcell;
    outcell<3> = incell<2>;
    outcell<2> = incell<1>;
    outcell<1> = incell<0>;
    outcell<0> = incell<0> EOR incell<3>;
    return outcell;
```

### Library pseudocode for aarch64/functions/pac/computepac/TweakCellRot

```
// TweakCellRot()
// =====

bits(4) TweakCellRot(bits(4) incell)
    bits(4) outcell;
    outcell<3> = incell<0> EOR incell<1>;
    outcell<2> = incell<3>;
    outcell<1> = incell<2>;
    outcell<0> = incell<1>;
    return outcell;
```

## Library pseudocode for aarch64/functions/pac/computepac/TweakInvShuffle

```
// TweakInvShuffle()
// =====

bits(64) TweakInvShuffle(bits(64) indata)
    bits(64) outdata;
    outdata<3:0> = TweakCellInvRot(indata<51:48>);
    outdata<7:4> = indata<55:52>;
    outdata<11:8> = indata<23:20>;
    outdata<15:12> = indata<27:24>;
    outdata<19:16> = indata<3:0>;
    outdata<23:20> = indata<7:4>;
    outdata<27:24> = TweakCellInvRot(indata<11:8>);
    outdata<31:28> = indata<15:12>;
    outdata<35:32> = TweakCellInvRot(indata<31:28>);
    outdata<39:36> = TweakCellInvRot(indata<63:60>);
    outdata<43:40> = TweakCellInvRot(indata<59:56>);
    outdata<47:44> = TweakCellInvRot(indata<19:16>);
    outdata<51:48> = indata<35:32>;
    outdata<55:52> = indata<39:36>;
    outdata<59:56> = indata<43:40>;
    outdata<63:60> = TweakCellInvRot(indata<47:44>);
    return outdata;
```

## Library pseudocode for aarch64/functions/pac/computepac/TweakShuffle

```
// TweakShuffle()
// =====

bits(64) TweakShuffle(bits(64) indata)
    bits(64) outdata;
    outdata<3:0> = indata<19:16>;
    outdata<7:4> = indata<23:20>;
    outdata<11:8> = TweakCellRot(indata<27:24>);
    outdata<15:12> = indata<31:28>;
    outdata<19:16> = TweakCellRot(indata<47:44>);
    outdata<23:20> = indata<11:8>;
    outdata<27:24> = indata<15:12>;
    outdata<31:28> = TweakCellRot(indata<35:32>);
    outdata<35:32> = indata<51:48>;
    outdata<39:36> = indata<55:52>;
    outdata<43:40> = indata<59:56>;
    outdata<47:44> = TweakCellRot(indata<63:60>);
    outdata<51:48> = TweakCellRot(indata<3:0>);
    outdata<55:52> = indata<7:4>;
    outdata<59:56> = TweakCellRot(indata<43:40>);
    outdata<63:60> = TweakCellRot(indata<39:36>);
    return outdata;
```

## Library pseudocode for aarch64/functions/pac/computepac/bits(64)

```
array bits(64) RC[0..4];
```

## Library pseudocode for aarch64/functions/pac/pac/HaveEnhancedPAC

```
// HaveEnhancedPAC()
// =====
// Returns TRUE if support for EnhancedPAC is implemented, FALSE otherwise.

boolean HaveEnhancedPAC()
    return ( HavePACExt()
        && boolean IMPLEMENTATION_DEFINED "Has enhanced PAC functionality" );
```

### Library pseudocode for aarch64/functions/pac/pac/HaveEnhancedPAC2

```
// HaveEnhancedPAC2()
// =====
// Returns TRUE if support for EnhancedPAC2 is implemented, FALSE otherwise.

boolean HaveEnhancedPAC2()
    return HasArchVersion\(ARMv8p6\) || (HasArchVersion\(ARMv8p3\) && boolean IMPLEMENTATION_DEFINED "Has enhanced PAC2")
```

### Library pseudocode for aarch64/functions/pac/pac/HaveFPAC

```
// HaveFPAC()
// =====
// Returns TRUE if support for FPAC is implemented, FALSE otherwise.

boolean HaveFPAC()
    return HaveEnhancedPAC2\(\) && boolean IMPLEMENTATION_DEFINED "Has FPAC functionality";
```

### Library pseudocode for aarch64/functions/pac/pac/HaveFPACCombined

```
// HaveFPACCombined()
// =====
// Returns TRUE if support for FPACCombined is implemented, FALSE otherwise.

boolean HaveFPACCombined()
    return HaveFPAC\(\) && boolean IMPLEMENTATION_DEFINED "Has FPAC Combined functionality";
```

### Library pseudocode for aarch64/functions/pac/pac/HavePACExt

```
// HavePACExt()
// =====
// Returns TRUE if support for the PAC extension is implemented, FALSE otherwise.

boolean HavePACExt()
    return HasArchVersion\(ARMv8p3\);
```

### Library pseudocode for aarch64/functions/pac/pac/PtrHasUpperAndLowerAddRanges

```
// PtrHasUpperAndLowerAddRanges()
// =====
// Returns TRUE if the pointer has upper and lower address ranges, FALSE otherwise.

boolean PtrHasUpperAndLowerAddRanges()
    regime = TranslationRegime(PSTATE.EL, AccType\_NORMAL);
    return HasUnprivileged(regime);
```

## Library pseudocode for aarch64/functions/pac/strip/Strip

```
// Strip()
// =====
// Strip() returns a 64-bit value containing A, but replacing the pointer authentication
// code field bits with the extension of the address bits. This can apply to either
// instructions or data, where, as the use of tagged pointers is distinct, it might be
// handled differently.

bits(64) Strip(bits(64) A, boolean data)
    bits(64) original_ptr;
    bits(64) extfield;
    boolean tbi = EffectiveTBI(A, !data, PSTATE.EL) == '1';
    integer bottom_PAC_bit = CalculateBottomPACBit(A<55>);
    extfield = Replicate(A<55>, 64);

    if tbi then
        original_ptr = A<63:56>:extfield< 56-bottom_PAC_bit-1:0>:A<bottom_PAC_bit-1:0>;
    else
        original_ptr = extfield< 64-bottom_PAC_bit-1:0>:A<bottom_PAC_bit-1:0>;

    return original_ptr;
```

## Library pseudocode for aarch64/functions/pac/trappacuse/TrapPACUse

```
// TrapPACUse()
// =====
// Used for the trapping of the pointer authentication functions by higher exception
// levels.

TrapPACUse(bits(2) target_el)
    assert HaveEL(target_el) && target_el != EL0 && UInt(target_el) >= UInt(PSTATE.EL);

    bits(64) preferred_exception_return = ThisInstrAddr();
    ExceptionRecord exception;
    vect_offset = 0;
    exception = ExceptionSyndrome(Exception\_PACTrap);
    AArch64.TakeException(target_el, exception, preferred_exception_return, vect_offset);
```



## Library pseudocode for aarch64/functions/ras/AArch64.ESBOperation

```
// AArch64.ESBOperation()
// =====
// Perform the AArch64 ESB operation, either for ESB executed in AArch64 state, or for
// ESB in AArch32 state when SError interrupts are routed to an Exception level using
// AArch64

AArch64.ESBOperation()

    route_to_el3 = HaveEL(EL3) && SCR_EL3.EA == '1';
    route_to_el2 = (EL2Enabled() &&
                    (HCR_EL2.TGE == '1' || HCR_EL2.AMO == '1'));

    target = if route_to_el3 then EL3 elsif route_to_el2 then EL2 else EL1;

    if target == EL1 then
        mask_active = PSTATE.EL IN {EL0, EL1};
    elsif HaveVirtHostExt() && target == EL2 && HCR_EL2.<E2H,TGE> == '11' then
        mask_active = PSTATE.EL IN {EL0, EL2};
    else
        mask_active = PSTATE.EL == target;

    mask_set = (PSTATE.A == '1' && (!HaveDoubleFaultExt() || SCR_EL3.EA == '0' ||
                                     PSTATE.EL != EL3 || SCR_EL3.NMEA == '0'));
    intdis = Halted() || ExternalDebugInterruptsDisabled(target);
    masked = (UInt(target) < UInt(PSTATE.EL)) || intdis || (mask_active && mask_set);

    // Check for a masked Physical SError pending that can be synchronized
    // by an Error synchronization event.
    if masked && IsSynchronizablePhysicalSErrorPending() then
        // This function might be called for an interworking case, and INTdis is masking
        // the SError interrupt.
        if ELUsingAArch32(S1TranslationRegime()) then
            syndrome32 = AArch32.PhysicalSErrorSyndrome();
            DISR = AArch32.ReportDeferredSError(syndrome32.AET, syndrome32.ExT);
        else
            implicit_esb = FALSE;
            syndrome64 = AArch64.PhysicalSErrorSyndrome(implicit_esb);
            DISR_EL1 = AArch64.ReportDeferredSError(syndrome64);
            ClearPendingPhysicalSError(); // Set ISR_EL1.A to 0

    return;
```

## Library pseudocode for aarch64/functions/ras/AArch64.PhysicalSErrorSyndrome

```
// Return the SError syndrome
bits(25) AArch64.PhysicalSErrorSyndrome(boolean implicit_esb);
```

## Library pseudocode for aarch64/functions/ras/AArch64.ReportDeferredSError

```
// AArch64.ReportDeferredSError()
// =====
// Generate deferred SError syndrome

bits(64) AArch64.ReportDeferredSError(bits(25) syndrome)
    bits(64) target;
    target<31> = '1'; // A
    target<24> = syndrome<24>; // IDS
    target<23:0> = syndrome<23:0>; // ISS
    return target;
```

## Library pseudocode for aarch64/functions/ras/AArch64.vESBOperation

```
// AArch64.vESBOperation()
// =====
// Perform the AArch64 ESB operation for virtual SError interrupts, either for ESB
// executed in AArch64 state, or for ESB in AArch32 state with EL2 using AArch64 state

AArch64.vESBOperation()
    assert PSTATE.EL IN {EL0, EL1} && EL2Enabled();

    // If physical SError interrupts are routed to EL2, and TGE is not set, then a virtual
    // SError interrupt might be pending
    vSEI_enabled = HCR_EL2.TGE == '0' && HCR_EL2.AMO == '1';
    vSEI_pending = vSEI_enabled && HCR_EL2.VSE == '1';
    vintdis      = Halted() || ExternalDebugInterruptsDisabled(EL1);
    vmasked      = vintdis || PSTATE.A == '1';

    // Check for a masked virtual SError pending
    if vSEI_pending && vmasked then
        // This function might be called for the interworking case, and INTdis is masking
        // the virtual SError interrupt.
        if ELUsingAArch32(EL1) then
            VDISR = AArch32.ReportDeferredSError(VDFSR<15:14>, VDFSR<12>);
        else
            VDISR_EL2 = AArch64.ReportDeferredSError(VSESR_EL2<24:0>);
            HCR_EL2.VSE = '0'; // Clear pending virtual SError

    return;
```

## Library pseudocode for aarch64/functions/registers/AArch64.MaybeZeroRegisterUppers

```
// AArch64.MaybeZeroRegisterUppers()
// =====
// On taking an exception to AArch64 from AArch32, it is CONSTRAINED UNPREDICTABLE whether the top
// 32 bits of registers visible at any lower Exception level using AArch32 are set to zero.

AArch64.MaybeZeroRegisterUppers()
    assert UsingAArch32(); // Always called from AArch32 state before entering AArch64 state

    if PSTATE.EL == EL0 && !ELUsingAArch32(EL1) then
        first = 0; last = 14; include_R15 = FALSE;
    elsif PSTATE.EL IN {EL0, EL1} && EL2Enabled() && !ELUsingAArch32(EL2) then
        first = 0; last = 30; include_R15 = FALSE;
    else
        first = 0; last = 30; include_R15 = TRUE;

    for n = first to last
        if (n != 15 || include_R15) && ConstrainUnpredictableBool(Unpredictable_ZEROUPPER) then
            _R[n]<63:32> = Zeros();

    return;
```

## Library pseudocode for aarch64/functions/registers/AArch64.ResetGeneralRegisters

```
// AArch64.ResetGeneralRegisters()
// =====

AArch64.ResetGeneralRegisters()

    for i = 0 to 30
        X[i] = bits(64) UNKNOWN;

    return;
```

## Library pseudocode for aarch64/functions/registers/AArch64.ResetSIMDFPRegisters

```
// AArch64.ResetSIMDFPRegisters()
// =====

AArch64.ResetSIMDFPRegisters()

    for i = 0 to 31
        V[i] = bits(128) UNKNOWN;

    return;
```

## Library pseudocode for aarch64/functions/registers/AArch64.ResetSpecialRegisters

```
// AArch64.ResetSpecialRegisters()
// =====

AArch64.ResetSpecialRegisters()

    // AArch64 special registers
    SP_EL0 = bits(64) UNKNOWN;
    SP_EL1 = bits(64) UNKNOWN;
    SPSR_EL1 = bits(64) UNKNOWN;
    ELR_EL1 = bits(64) UNKNOWN;
    if HaveEL\(EL2\) then
        SP_EL2 = bits(64) UNKNOWN;
        SPSR_EL2 = bits(64) UNKNOWN;
        ELR_EL2 = bits(64) UNKNOWN;
    if HaveEL\(EL3\) then
        SP_EL3 = bits(64) UNKNOWN;
        SPSR_EL3 = bits(64) UNKNOWN;
        ELR_EL3 = bits(64) UNKNOWN;

    // AArch32 special registers that are not architecturally mapped to AArch64 registers
    if HaveAArch32EL\(EL1\) then
        SPSR_fiq<31:0> = bits(32) UNKNOWN;
        SPSR_irq<31:0> = bits(32) UNKNOWN;
        SPSR_abt<31:0> = bits(32) UNKNOWN;
        SPSR_und<31:0> = bits(32) UNKNOWN;

    // External debug special registers
    DLR_EL0 = bits(64) UNKNOWN;
    DSPSR_EL0 = bits(64) UNKNOWN;

    return;
```

## Library pseudocode for aarch64/functions/registers/AArch64.ResetSystemRegisters

```
AArch64.ResetSystemRegisters(boolean cold_reset);
```

## Library pseudocode for aarch64/functions/registers/PC

```
// PC - non-assignment form
// =====
// Read program counter.

bits(64) PC[]
    return _PC;
```

## Library pseudocode for aarch64/functions/registers/SP

```
// SP[] - assignment form
// =====
// Write to stack pointer from either a 32-bit or a 64-bit value.

SP[] = bits(width) value
    assert width IN {32,64};
    if PSTATE.SP == '0' then
        SP_EL0 = ZeroExtend(value);
    else
        case PSTATE.EL of
            when EL0 SP_EL0 = ZeroExtend(value);
            when EL1 SP_EL1 = ZeroExtend(value);
            when EL2 SP_EL2 = ZeroExtend(value);
            when EL3 SP_EL3 = ZeroExtend(value);
        return;

// SP[] - non-assignment form
// =====
// Read stack pointer with implicit slice of 8, 16, 32 or 64 bits.

bits(width) SP[]
    assert width IN {8,16,32,64};
    if PSTATE.SP == '0' then
        return SP_EL0<width-1:0>;
    else
        case PSTATE.EL of
            when EL0 return SP_EL0<width-1:0>;
            when EL1 return SP_EL1<width-1:0>;
            when EL2 return SP_EL2<width-1:0>;
            when EL3 return SP_EL3<width-1:0>;
```

## Library pseudocode for aarch64/functions/registers/V

```
// V[] - assignment form
// =====
// Write to SIMD&FP register with implicit extension from
// 8, 16, 32, 64 or 128 bits.

V[integer n] = bits(width) value
    assert n >= 0 && n <= 31;
    assert width IN {8,16,32,64,128};
    integer vlen = if IsSVEEnabled(PSTATE.EL) then VL else 128;
    if ConstrainUnpredictableBool(Unpredictable_SVEZERoupper) then
        _Z[n] = ZeroExtend(value);
    else
        _Z[n]<vlen-1:0> = ZeroExtend(value);

// V[] - non-assignment form
// =====
// Read from SIMD&FP register with implicit slice of 8, 16
// 32, 64 or 128 bits.

bits(width) V[integer n]
    assert n >= 0 && n <= 31;
    assert width IN {8,16,32,64,128};
    return _Z[n]<width-1:0>;
```

## Library pseudocode for aarch64/functions/registers/Vpart

```
// Vpart[] - non-assignment form
// =====
// Reads a 128-bit SIMD&FP register in up to two parts:
// part 0 returns the bottom 8, 16, 32 or 64 bits of a value held in the register;
// part 1 returns the top half of the bottom 64 bits or the top half of the 128-bit
// value held in the register.

bits(width) Vpart[integer n, integer part]
    assert n >= 0 && n <= 31;
    assert part IN {0, 1};
    if part == 0 then
        assert width < 128;
        return V[n];
    else
        assert width IN {32,64};
        bits(128) vreg = V[n];
        return vreg<(width * 2)-1:width>;

// Vpart[] - assignment form
// =====
// Writes a 128-bit SIMD&FP register in up to two parts:
// part 0 zero extends a 8, 16, 32, or 64-bit value to fill the whole register;
// part 1 inserts a 64-bit value into the top half of the register.

Vpart[integer n, integer part] = bits(width) value
    assert n >= 0 && n <= 31;
    assert part IN {0, 1};
    if part == 0 then
        assert width < 128;
        V[n] = value;
    else
        assert width == 64;
        bits(64) vreg = V[n];
        V[n] = value<63:0> : vreg;
```

## Library pseudocode for aarch64/functions/registers/X

```
// X[] - assignment form
// =====
// Write to general-purpose register from either a 32-bit or a 64-bit value.

X[integer n] = bits(width) value
    assert n >= 0 && n <= 31;
    assert width IN {32,64};
    if n != 31 then
        _R[n] = ZeroExtend(value);
    return;

// X[] - non-assignment form
// =====
// Read from general-purpose register with implicit slice of 8, 16, 32 or 64 bits.

bits(width) X[integer n]
    assert n >= 0 && n <= 31;
    assert width IN {8,16,32,64};
    if n != 31 then
        return _R[n]<width-1:0>;
    else
        return Zeros(width);
```

## Library pseudocode for aarch64/functions/sve/AArch32.IsFPEnabled

```
// AArch32.IsFPEnabled()
// =====
// Returns TRUE if access to the SIMD&FP instructions or System registers are
// enabled at the target exception level in AArch32 state and FALSE otherwise.

boolean AArch32.IsFPEnabled(bits(2) el)
    if el == EL0 && !ELUsingAArch32\(EL1\) then
        return AArch64.IsFPEnabled\(el\);

    if HaveEL\(EL3\) && ELUsingAArch32\(EL3\) && !IsSecure\(\) then
        // Check if access disabled in NSACR
        if NSACR.cp10 == '0' then return FALSE;

    if el IN {EL0, EL1} then
        // Check if access disabled in CPACR
        case CPACR.cp10 of
            when '00' disabled = TRUE;
            when '01' disabled = el == EL0;
            when '10' disabled = ConstrainUnpredictableBool\(Unpredictable\_RESCPACR\);
            when '11' disabled = FALSE;
        if disabled then return FALSE;

    if el IN {EL0, EL1, EL2} && EL2Enabled\(\) then
        if !ELUsingAArch32\(EL2\) then
            return AArch64.IsFPEnabled\(EL2\);
        if HCPTR.TCP10 == '1' then return FALSE;

    if HaveEL\(EL3\) && !ELUsingAArch32\(EL3\) then
        // Check if access disabled in CPTR_EL3
        if CPTR_EL3.TFP == '1' then return FALSE;

    return TRUE;
```

## Library pseudocode for aarch64/functions/sve/AArch64.IsFPEnabled

```
// AArch64.IsFPEnabled()
// =====
// Returns TRUE if access to the SIMD&FP instructions or System registers are
// enabled at the target exception level in AArch64 state and FALSE otherwise.

boolean AArch64.IsFPEnabled(bits(2) el)
    // Check if access disabled in CPACR_EL1
    if el IN {EL0, EL1} && !IsInHost\(\) then
        // Check FP&SIMD at EL0/EL1
        case CPACR_EL1.FPEN of
            when 'x0' disabled = TRUE;
            when '01' disabled = el == EL0;
            when '11' disabled = FALSE;
        if disabled then return FALSE;

    // Check if access disabled in CPTR_EL2
    if el IN {EL0, EL1, EL2} && EL2Enabled\(\) then
        if HaveVirtHostExt\(\) && HCR_EL2.E2H == '1' then
            case CPTR_EL2.FPEN of
                when 'x0' disabled = TRUE;
                when '01' disabled = el == EL0 && HCR_EL2.TGE == '1';
                when '11' disabled = FALSE;
            if disabled then return FALSE;
        else
            if CPTR_EL2.TFP == '1' then return FALSE;

    // Check if access disabled in CPTR_EL3
    if HaveEL\(EL3\) then
        if CPTR_EL3.TFP == '1' then return FALSE;

    return TRUE;
```

## Library pseudocode for aarch64/functions/sve/AnyActiveElement

```
// AnyActiveElement()
// =====
// Return TRUE if there is at least one active element in mask. Otherwise,
// return FALSE.

boolean AnyActiveElement(bits(N) mask, integer esize)
    return LastActiveElement(mask, esize) >= 0;
```

## Library pseudocode for aarch64/functions/sve/CeilPow2

```
// CeilPow2()
// =====

// For a positive integer X, return the smallest power of 2 >= X

integer CeilPow2(integer x)
    if x == 0 then return 0;
    if x == 1 then return 2;
    return FloorPow2(x - 1) * 2;
```

## Library pseudocode for aarch64/functions/sve/CheckSVEEnabled

```
// CheckSVEEnabled()
// =====
// Checks for traps on SVE instructions and instructions that
// access SVE System registers.

CheckSVEEnabled()
    // Check if access disabled in CPACR_EL1
    if PSTATE.EL IN {EL0, EL1} && !IsInHost() then
        // Check SVE at EL0/EL1
        case CPACR_EL1.ZEN of
            when 'x0' disabled = TRUE;
            when '01' disabled = PSTATE.EL == EL0;
            when '11' disabled = FALSE;
        if disabled then SVEAccessTrap(EL1);

        // Check SIMD&FP at EL0/EL1
        case CPACR_EL1.FPEN of
            when 'x0' disabled = TRUE;
            when '01' disabled = PSTATE.EL == EL0;
            when '11' disabled = FALSE;
        if disabled then AArch64.AdvSIMDFPAccessTrap(EL1);

    // Check if access disabled in CPTR_EL2
    if PSTATE.EL IN {EL0, EL1, EL2} && EL2Enabled() then
        if HaveVirtHostExt() && HCR_EL2.E2H == '1' then
            // Check SVE at EL2
            case CPTR_EL2.ZEN of
                when 'x0' disabled = TRUE;
                when '01' disabled = PSTATE.EL == EL0 && HCR_EL2.TGE == '1';
                when '11' disabled = FALSE;
            if disabled then SVEAccessTrap(EL2);

            // Check SIMD&FP at EL2
            case CPTR_EL2.FPEN of
                when 'x0' disabled = TRUE;
                when '01' disabled = PSTATE.EL == EL0 && HCR_EL2.TGE == '1';
                when '11' disabled = FALSE;
            if disabled then AArch64.AdvSIMDFPAccessTrap(EL2);
        else
            if CPTR_EL2.TZ == '1' then SVEAccessTrap(EL2);
            if CPTR_EL2.TFP == '1' then AArch64.AdvSIMDFPAccessTrap(EL2);

    // Check if access disabled in CPTR_EL3
    if HaveEL(EL3) then
        if CPTR_EL3.EZ == '0' then SVEAccessTrap(EL3);
        if CPTR_EL3.TFP == '1' then AArch64.AdvSIMDFPAccessTrap(EL3);
```



## Library pseudocode for aarch64/functions/sve/DecodePredCount

```
// DecodePredCount()
// =====

integer DecodePredCount(bits(5) pattern, integer esize)
    integer elements = VL DIV esize;
    integer numElem;
    case pattern of
        when '00000' numElem = FloorPow2(elements);
        when '00001' numElem = if elements >= 1 then 1 else 0;
        when '00010' numElem = if elements >= 2 then 2 else 0;
        when '00011' numElem = if elements >= 3 then 3 else 0;
        when '00100' numElem = if elements >= 4 then 4 else 0;
        when '00101' numElem = if elements >= 5 then 5 else 0;
        when '00110' numElem = if elements >= 6 then 6 else 0;
        when '00111' numElem = if elements >= 7 then 7 else 0;
        when '01000' numElem = if elements >= 8 then 8 else 0;
        when '01001' numElem = if elements >= 16 then 16 else 0;
        when '01010' numElem = if elements >= 32 then 32 else 0;
        when '01011' numElem = if elements >= 64 then 64 else 0;
        when '01100' numElem = if elements >= 128 then 128 else 0;
        when '01101' numElem = if elements >= 256 then 256 else 0;
        when '11101' numElem = elements - (elements MOD 4);
        when '11110' numElem = elements - (elements MOD 3);
        when '11111' numElem = elements;
        otherwise    numElem = 0;
    return numElem;
```

## Library pseudocode for aarch64/functions/sve/ElemFFR

```
// ElemFFR[] - non-assignment form
// =====

bit ElemFFR[integer e, integer esize]
    return ElemP[_FFR, e, esize];

// ElemFFR[] - assignment form
// =====

ElemFFR[integer e, integer esize] = bit value
    integer psize = esize DIV 8;
    integer n = e * psize;
    assert n >= 0 && (n + psize) <= PL;
    _FFR<n+psize-1:n> = ZeroExtend(value, psize);
    return;
```

## Library pseudocode for aarch64/functions/sve/ElemP

```
// ElemP[] - non-assignment form
// =====

bit ElemP[bits(N) pred, integer e, integer esize]
    integer n = e * (esize DIV 8);
    assert n >= 0 && n < N;
    return pred<n>;

// ElemP[] - assignment form
// =====

ElemP[bits(N) &pred, integer e, integer esize] = bit value
    integer psize = esize DIV 8;
    integer n = e * psize;
    assert n >= 0 && (n + psize) <= N;
    pred<n+psize-1:n> = ZeroExtend(value, psize);
    return;
```

## Library pseudocode for aarch64/functions/sve/FFR

```
// FFR[] - non-assignment form
// =====

bits(width) FFR[]
    assert width == PL;
    return _FFR<width-1:0>;

// FFR[] - assignment form
// =====

FFR[] = bits(width) value
    assert width == PL;
    if ConstrainUnpredictableBool(Unpredictable\_SVEZEROUPPER) then
        _FFR = ZeroExtend(value);
    else
        _FFR<width-1:0> = value;
```

## Library pseudocode for aarch64/functions/sve/FPCompareNE

```
// FPCompareNE()
// =====

boolean FPCompareNE(bits(N) op1, bits(N) op2, FPCRTType fpcr)
    assert N IN {16,32,64};
    (type1,sign1,value1) = FPUntpack(op1, fpcr);
    (type2,sign2,value2) = FPUntpack(op2, fpcr);
    op1_nan = type1 IN {FPTType\_SNaN, FPTType\_QNaN};
    op2_nan = type2 IN {FPTType\_SNaN, FPTType\_QNaN};

    if op1_nan || op2_nan then
        result = TRUE;
        if type1 == FPTType\_SNaN || type2 == FPTType\_SNaN then
            FPProcessException(FPExc\_InvalidOp, fpcr);
    else // All non-NaN cases can be evaluated on the values produced by FPUntpack()
        result = (value1 != value2);

        FPProcessDenorms(type1, type2, N, fpcr);

    return result;
```

## Library pseudocode for aarch64/functions/sve/FPCompareUN

```
// FPCompareUN()
// =====

boolean FPCompareUN(bits(N) op1, bits(N) op2, FPCRTType fpcr)
    assert N IN {16,32,64};
    (type1,sign1,value1) = FPUntpack(op1, fpcr);
    (type2,sign2,value2) = FPUntpack(op2, fpcr);

    if type1 == FPTType\_SNaN || type2 == FPTType\_SNaN then
        FPProcessException(FPExc\_InvalidOp, fpcr);

    result = type1 IN {FPTType\_SNaN, FPTType\_QNaN} || type2 IN {FPTType\_SNaN, FPTType\_QNaN};

    if !result then
        FPProcessDenorms(type1, type2, N, fpcr);

    return result;
```

## Library pseudocode for aarch64/functions/sve/FPConvertSVE

```
// FPConvertSVE()
// =====

bits(M) FPConvertSVE(bits(N) op, FPCRTType fpcr, FPRounding rounding)
    fpcr.AHP = '0';
    return FPConvert(op, fpcr, rounding);

// FPConvertSVE()
// =====

bits(M) FPConvertSVE(bits(N) op, FPCRTType fpcr)
    fpcr.AHP = '0';
    return FPConvert(op, fpcr, FPRoundingMode(fpcr));
```

## Library pseudocode for aarch64/functions/sve/FPExpA

```
// FPExpA()
// =====

bits(N) FPExpA(bits(N) op)
    assert N IN {16,32,64};
    bits(N) result;
    bits(N) coeff;
    integer idx = if N == 16 then UInt(op<4:0>) else UInt(op<5:0>);
    coeff = FPExpCoefficient[idx];
    if N == 16 then
        result<15:0> = '0':op<9:5>:coeff<9:0>;
    elsif N == 32 then
        result<31:0> = '0':op<13:6>:coeff<22:0>;
    else // N == 64
        result<63:0> = '0':op<16:6>:coeff<51:0>;

    return result;
```



```

// FPExpCoefficient()
// =====

bits(N) FPExpCoefficient[integer index]
  assert N IN {16,32,64};
  integer result;

  if N == 16 then
    case index of
      when 0 result = 0x0000;
      when 1 result = 0x0016;
      when 2 result = 0x002d;
      when 3 result = 0x0045;
      when 4 result = 0x005d;
      when 5 result = 0x0075;
      when 6 result = 0x008e;
      when 7 result = 0x00a8;
      when 8 result = 0x00c2;
      when 9 result = 0x00dc;
      when 10 result = 0x00f8;
      when 11 result = 0x0114;
      when 12 result = 0x0130;
      when 13 result = 0x014d;
      when 14 result = 0x016b;
      when 15 result = 0x0189;
      when 16 result = 0x01a8;
      when 17 result = 0x01c8;
      when 18 result = 0x01e8;
      when 19 result = 0x0209;
      when 20 result = 0x022b;
      when 21 result = 0x024e;
      when 22 result = 0x0271;
      when 23 result = 0x0295;
      when 24 result = 0x02ba;
      when 25 result = 0x02e0;
      when 26 result = 0x0306;
      when 27 result = 0x032e;
      when 28 result = 0x0356;
      when 29 result = 0x037f;
      when 30 result = 0x03a9;
      when 31 result = 0x03d4;

    elsif N == 32 then
      case index of
        when 0 result = 0x000000;
        when 1 result = 0x0164d2;
        when 2 result = 0x02cd87;
        when 3 result = 0x043a29;
        when 4 result = 0x05aac3;
        when 5 result = 0x071f62;
        when 6 result = 0x08980f;
        when 7 result = 0x0a14d5;
        when 8 result = 0x0b95c2;
        when 9 result = 0x0dladf;
        when 10 result = 0x0ea43a;
        when 11 result = 0x1031dc;
        when 12 result = 0x11c3d3;
        when 13 result = 0x135a2b;
        when 14 result = 0x14f4f0;
        when 15 result = 0x16942d;
        when 16 result = 0x1837f0;
        when 17 result = 0x19e046;
        when 18 result = 0x1b8d3a;
        when 19 result = 0x1d3eda;
        when 20 result = 0x1ef532;
        when 21 result = 0x20b051;
        when 22 result = 0x227043;
        when 23 result = 0x243516;
        when 24 result = 0x25fed7;
        when 25 result = 0x27cd94;

```

```

when 26 result = 0x29a15b;
when 27 result = 0x2b7a3a;
when 28 result = 0x2d583f;
when 29 result = 0x2f3b79;
when 30 result = 0x3123f6;
when 31 result = 0x3311c4;
when 32 result = 0x3504f3;
when 33 result = 0x36fd92;
when 34 result = 0x38fbaf;
when 35 result = 0x3aff5b;
when 36 result = 0x3d08a4;
when 37 result = 0x3f179a;
when 38 result = 0x412c4d;
when 39 result = 0x4346cd;
when 40 result = 0x45672a;
when 41 result = 0x478d75;
when 42 result = 0x49b9be;
when 43 result = 0x4bec15;
when 44 result = 0x4e248c;
when 45 result = 0x506334;
when 46 result = 0x52a81e;
when 47 result = 0x54f35b;
when 48 result = 0x5744fd;
when 49 result = 0x599d16;
when 50 result = 0x5bfbb8;
when 51 result = 0x5e60f5;
when 52 result = 0x60ccdf;
when 53 result = 0x633f89;
when 54 result = 0x65b907;
when 55 result = 0x68396a;
when 56 result = 0x6ac0c7;
when 57 result = 0x6d4f30;
when 58 result = 0x6fe4ba;
when 59 result = 0x728177;
when 60 result = 0x75257d;
when 61 result = 0x77d0df;
when 62 result = 0x7a83b3;
when 63 result = 0x7d3e0c;

```

```

else // N == 64

```

```

    case index of

```

```

        when 0 result = 0x00000000000000;
        when 1 result = 0x02C9A3E778061;
        when 2 result = 0x059B0D3158574;
        when 3 result = 0x0874518759BC8;
        when 4 result = 0x0B5586CF9890F;
        when 5 result = 0x0E3EC32D3D1A2;
        when 6 result = 0x11301D0125B51;
        when 7 result = 0x1429AAEA92DE0;
        when 8 result = 0x172B83C7D517B;
        when 9 result = 0x1A35BEB6FCB75;
        when 10 result = 0x1D4873168B9AA;
        when 11 result = 0x2063B88628CD6;
        when 12 result = 0x2387A6E756238;
        when 13 result = 0x26B4565E27CDD;
        when 14 result = 0x29E9DF51FDEE1;
        when 15 result = 0x2D285A6E4030B;
        when 16 result = 0x306FE0A31B715;
        when 17 result = 0x33C08B26416FF;
        when 18 result = 0x371A7373AA9CB;
        when 19 result = 0x3A7DB34E59FF7;
        when 20 result = 0x3DEA64C123422;
        when 21 result = 0x4160A21F72E2A;
        when 22 result = 0x44E086061892D;
        when 23 result = 0x486A2B5C13CD0;
        when 24 result = 0x4BFDAD5362A27;
        when 25 result = 0x4F9B2769D2CA7;
        when 26 result = 0x5342B569D4F82;
        when 27 result = 0x56F4736B527DA;
        when 28 result = 0x5AB07DD485429;

```

```

when 29 result = 0x5E76F15AD2148;
when 30 result = 0x6247EB03A5585;
when 31 result = 0x6623882552225;
when 32 result = 0x6A09E667F3BCD;
when 33 result = 0x6DFB23C651A2F;
when 34 result = 0x71F75E8EC5F74;
when 35 result = 0x75FEB564267C9;
when 36 result = 0x7A11473EB0187;
when 37 result = 0x7E2F336CF4E62;
when 38 result = 0x82589994CCE13;
when 39 result = 0x868D99B4492ED;
when 40 result = 0x8ACE5422AA0DB;
when 41 result = 0x8F1AE99157736;
when 42 result = 0x93737B0CDC5E5;
when 43 result = 0x97D829FDE4E50;
when 44 result = 0x9C49182A3F090;
when 45 result = 0xA0C667B5DE565;
when 46 result = 0xA5503B23E255D;
when 47 result = 0xA9E6B5579FDBF;
when 48 result = 0xAE89F995AD3AD;
when 49 result = 0xB33A2B84F15FB;
when 50 result = 0xB7F76F2FB5E47;
when 51 result = 0xBCC1E904BC1D2;
when 52 result = 0xC199BDD85529C;
when 53 result = 0xC67F12E57D14B;
when 54 result = 0xCB720DCEF9069;
when 55 result = 0xD072D4A07897C;
when 56 result = 0xD5818DCFBA487;
when 57 result = 0xDA9E603DB3285;
when 58 result = 0xDFC97337B9B5F;
when 59 result = 0xE502EE78B3FF6;
when 60 result = 0xEA4AFA2A490DA;
when 61 result = 0xEFA1BEE615A27;
when 62 result = 0xF50765B6E4540;
when 63 result = 0xFA7C1819E90D8;

```

```
return result<N-1:0>;
```

### Library pseudocode for aarch64/functions/sve/FPMinNormal

```

// FPMinNormal()
// =====

bits(N) FPMinNormal(bit sign)
    assert N IN {16,32,64};
    constant integer E = (if N == 16 then 5 elsif N == 32 then 8 else 11);
    constant integer F = N - (E + 1);
    exp = Zeros(E-1):'1';
    frac = Zeros(F);
    return sign : exp : frac;

```

### Library pseudocode for aarch64/functions/sve/FPOne

```

// FPOne()
// =====

bits(N) FPOne(bit sign)
    assert N IN {16,32,64};
    constant integer E = (if N == 16 then 5 elsif N == 32 then 8 else 11);
    constant integer F = N - (E + 1);
    exp = '0':Ones(E-1);
    frac = Zeros(F);
    return sign : exp : frac;

```

## Library pseudocode for aarch64/functions/sve/FPPointFive

```
// FPPointFive()
// =====

bits(N) FPPointFive(bit sign)
    assert N IN {16,32,64};
    constant integer E = (if N == 16 then 5 elsif N == 32 then 8 else 11);
    constant integer F = N - (E + 1);
    exp = '0':Ones(E-2):'0';
    frac = Zeros(F);
    return sign : exp : frac;
```

## Library pseudocode for aarch64/functions/sve/FPProcess

```
// FPProcess()
// =====

bits(N) FPProcess(bits(N) input)
    bits(N) result;
    assert N IN {16,32,64};
    FPCRTType fpcr = FPCR[];
    (fptype,sign,value) = FPUnpack(input, fpcr);

    if fptype == FPTType\_SNaN || fptype == FPTType\_QNaN then
        result = FPProcessNaN(fptype, input, fpcr);
    elsif fptype == FPTType\_Infinity then
        result = FPInfinity(sign);
    elsif fptype == FPTType\_Zero then
        result = FPZero(sign);
    else
        result = FPRound(value, fpcr);

        FPProcessDenorm(fptype, N, fpcr);

    return result;
```

## Library pseudocode for aarch64/functions/sve/FPScale

```
// FPScale()
// =====

bits(N) FPScale(bits (N) op, integer scale, FPCRTType fpcr)
    assert N IN {16,32,64};
    (fptype,sign,value) = FPUnpack(op, fpcr);

    if fptype == FPTType\_SNaN || fptype == FPTType\_QNaN then
        result = FPProcessNaN(fptype, op, fpcr);
    elsif fptype == FPTType\_Zero then
        result = FPZero(sign);
    elsif fptype == FPTType\_Infinity then
        result = FPInfinity(sign);
    else
        result = FPRound(value * (2.0scale), fpcr);

        FPProcessDenorm(fptype, N, fpcr);

    return result;
```



## Library pseudocode for aarch64/functions/sve/FPTrigMAdd

```
// FPTrigMAdd()
// =====

bits(N) FPTrigMAdd(integer x, bits(N) op1, bits(N) op2, FPCRTType fpcr)
    assert N IN {16,32,64};
    assert x >= 0;
    assert x < 8;
    bits(N) coeff;

    if op2<N-1> == '1' then
        x = x + 8;

    coeff = FPTrigMAddCoefficient[x];
    op2   = FPAbs(op2);
    result = FPMulAdd(coeff, op1, op2, fpcr);
    return result;
```

## Library pseudocode for aarch64/functions/sve/FPTrigMAddCoefficient

```
// FPTrigMAddCoefficient()
// =====

bits(N) FPTrigMAddCoefficient[integer index]
  assert N IN {16,32,64};
  integer result;

  if N == 16 then
    case index of
      when 0 result = 0x3c00;
      when 1 result = 0xb155;
      when 2 result = 0x2030;
      when 3 result = 0x0000;
      when 4 result = 0x0000;
      when 5 result = 0x0000;
      when 6 result = 0x0000;
      when 7 result = 0x0000;
      when 8 result = 0x3c00;
      when 9 result = 0xb800;
      when 10 result = 0x293a;
      when 11 result = 0x0000;
      when 12 result = 0x0000;
      when 13 result = 0x0000;
      when 14 result = 0x0000;
      when 15 result = 0x0000;
    elsif N == 32 then
      case index of
        when 0 result = 0x3f800000;
        when 1 result = 0xbe2aaaab;
        when 2 result = 0x3c088886;
        when 3 result = 0xb95008b9;
        when 4 result = 0x36369d6d;
        when 5 result = 0x00000000;
        when 6 result = 0x00000000;
        when 7 result = 0x00000000;
        when 8 result = 0x3f800000;
        when 9 result = 0xbf000000;
        when 10 result = 0x3d2aaaa6;
        when 11 result = 0xbab60705;
        when 12 result = 0x37cd37cc;
        when 13 result = 0x00000000;
        when 14 result = 0x00000000;
        when 15 result = 0x00000000;
      else // N == 64
        case index of
          when 0 result = 0x3ff0000000000000;
          when 1 result = 0xbfc5555555555543;
          when 2 result = 0x3f8111111110f30c;
          when 3 result = 0xbf2a01a019b92fc6;
          when 4 result = 0x3ec71de351f3d22b;
          when 5 result = 0xbe5ae5e2b60f7b91;
          when 6 result = 0x3de5d8408868552f;
          when 7 result = 0x0000000000000000;
          when 8 result = 0x3ff0000000000000;
          when 9 result = 0xbfe0000000000000;
          when 10 result = 0x3fa5555555555536;
          when 11 result = 0xbf56c16c16c13a0b;
          when 12 result = 0x3efa01a019b1e8d8;
          when 13 result = 0xbe927e4f7282f468;
          when 14 result = 0x3e21ee96d2641b13;
          when 15 result = 0xbda8f76380fbb401;

  return result<N-1:0>;
```

## Library pseudocode for aarch64/functions/sve/FPTrigSMul

```
// FPTrigSMul()
// =====

bits(N) FPTrigSMul(bits(N) op1, bits(N) op2, FPCRTType fpcr)
    assert N IN {16,32,64};
    result = FPMul(op1, op1, fpcr);
    fpexc = FALSE;
    (fptype, sign, value) = FPUntpack(result, fpcr, fpexc);

    if !(fptype IN {FPTType\_QNaN, FPTType\_SNaN}) then
        result<N-1> = op2<0>;

    return result;
```

## Library pseudocode for aarch64/functions/sve/FPTrigSSel

```
// FPTrigSSel()
// =====

bits(N) FPTrigSSel(bits(N) op1, bits(N) op2)
    assert N IN {16,32,64};
    bits(N) result;

    if op2<0> == '1' then
        result = FP0ne(op2<1>);
    elsif op2<1> == '1' then
        result = FPNeg(op1);
    else
        result = op1;

    return result;
```

## Library pseudocode for aarch64/functions/sve/FirstActive

```
// FirstActive()
// =====

bit FirstActive(bits(N) mask, bits(N) x, integer esize)
    integer elements = N DIV (esize DIV 8);
    for e = 0 to elements-1
        if ElemP[mask, e, esize] == '1' then return ElemP[x, e, esize];
    return '0';
```

## Library pseudocode for aarch64/functions/sve/FloorPow2

```
// FloorPow2()
// =====
// For a positive integer X, return the largest power of 2 <= X

integer FloorPow2(integer x)
    assert x >= 0;
    integer n = 1;
    if x == 0 then return 0;
    while x >= 2^n do
        n = n + 1;
    return 2^(n - 1);
```

## Library pseudocode for aarch64/functions/sve/HaveSVE

```
// HaveSVE()
// =====

boolean HaveSVE()
    return HasArchVersion(ARMv8p2) && boolean IMPLEMENTATION_DEFINED "Have SVE ISA";
```

### Library pseudocode for aarch64/functions/sve/HaveSVEFP32MatMulExt

```
// HaveSVEFP32MatMulExt()
// =====
// Returns TRUE if single-precision floating-point matrix multiply instruction support implemented and FALSE otherwise.

boolean HaveSVEFP32MatMulExt()
    return HaveSVE() && boolean IMPLEMENTATION_DEFINED "Have SVE FP32 Matrix Multiply extension";
```

### Library pseudocode for aarch64/functions/sve/HaveSVEFP64MatMulExt

```
// HaveSVEFP64MatMulExt()
// =====
// Returns TRUE if double-precision floating-point matrix multiply instruction support implemented and FALSE otherwise.

boolean HaveSVEFP64MatMulExt()
    return HaveSVE() && boolean IMPLEMENTATION_DEFINED "Have SVE FP64 Matrix Multiply extension";
```

### Library pseudocode for aarch64/functions/sve/ImplementedSVEVectorLength

```
// ImplementedSVEVectorLength()
// =====
// Reduce SVE vector length to a supported value (e.g. power of two)

integer ImplementedSVEVectorLength(integer nbits)
    return integer IMPLEMENTATION_DEFINED;
```

### Library pseudocode for aarch64/functions/sve/IsEven

```
// IsEven()
// =====

boolean IsEven(integer val)
    return val MOD 2 == 0;
```

### Library pseudocode for aarch64/functions/sve/IsFPEnabled

```
// IsFPEnabled()
// =====
// Returns TRUE if accesses to the Advanced SIMD and floating-point
// registers are enabled at the target exception level in the current
// execution state and FALSE otherwise.

boolean IsFPEnabled(bits(2) el)
    if ELUsingAArch32(el) then
        return AArch32.IsFPEnabled(el);
    else
        return AArch64.IsFPEnabled(el);
```

## Library pseudocode for aarch64/functions/sve/IsSVEEnabled

```
// IsSVEEnabled()
// =====
// Returns TRUE if access to SVE instructions and System registers is
// enabled at the target exception level and FALSE otherwise.

boolean IsSVEEnabled(bits(2) el)
    if ELUsingAArch32(el) then
        return FALSE;

    // Check if access disabled in CPACR_EL1
    if el IN {EL0, EL1} && !IsInHost() then
        // Check SVE at EL0/EL1
        case CPACR_EL1.ZEN of
            when 'x0' disabled = TRUE;
            when '01' disabled = el == EL0;
            when '11' disabled = FALSE;
        if disabled then return FALSE;

    // Check if access disabled in CPTR_EL2
    if el IN {EL0, EL1, EL2} && EL2Enabled() then
        if HaveVirtHostExt() && HCR_EL2.E2H == '1' then
            case CPTR_EL2.ZEN of
                when 'x0' disabled = TRUE;
                when '01' disabled = el == EL0 && HCR_EL2.TGE == '1';
                when '11' disabled = FALSE;
            if disabled then return FALSE;
        else
            if CPTR_EL2.TZ == '1' then return FALSE;

    // Check if access disabled in CPTR_EL3
    if HaveEL(EL3) then
        if CPTR_EL3.EZ == '0' then return FALSE;

    return TRUE;
```

## Library pseudocode for aarch64/functions/sve/LastActive

```
// LastActive()
// =====

bit LastActive(bits(N) mask, bits(N) x, integer esize)
    integer elements = N DIV (esize DIV 8);
    for e = elements-1 downto 0
        if ElemP[mask, e, esize] == '1' then return ElemP[x, e, esize];
    return '0';
```

## Library pseudocode for aarch64/functions/sve/LastActiveElement

```
// LastActiveElement()
// =====

integer LastActiveElement(bits(N) mask, integer esize)
    assert esize IN {8, 16, 32, 64, 128};
    integer elements = VL DIV esize;
    for e = elements-1 downto 0
        if ElemP[mask, e, esize] == '1' then return e;
    return -1;
```

## Library pseudocode for aarch64/functions/sve/MaybeZeroSVEUppers

```
// MaybeZeroSVEUppers()
// =====

MaybeZeroSVEUppers(bits(2) target_el)
    boolean lower_enabled;

    if UInt(target_el) <= UInt(PSTATE.EL) || !IsSVEEnabled(target_el) then
        return;

    if target_el == EL3 then
        if EL2Enabled() then
            lower_enabled = IsFPEEnabled(EL2);
        else
            lower_enabled = IsFPEEnabled(EL1);
    elsif target_el == EL2 then
        assert !ELUsingAArch32(EL2);
        if HCR_EL2.TGE == '0' then
            lower_enabled = IsFPEEnabled(EL1);
        else
            lower_enabled = IsFPEEnabled(EL0);
    else
        assert target_el == EL1 && !ELUsingAArch32(EL1);
        lower_enabled = IsFPEEnabled(EL0);

    if lower_enabled then
        integer vl = if IsSVEEnabled(PSTATE.EL) then VL else 128;
        integer pl = vl DIV 8;
        for n = 0 to 31
            if ConstrainUnpredictableBool(Unpredictable_SVEZEROUPPER) then
                _Z[n] = ZeroExtend(_Z[n]<vl-1:0>);
        for n = 0 to 15
            if ConstrainUnpredictableBool(Unpredictable_SVEZEROUPPER) then
                _P[n] = ZeroExtend(_P[n]<pl-1:0>);
        if ConstrainUnpredictableBool(Unpredictable_SVEZEROUPPER) then
            _FFR = ZeroExtend(_FFR<pl-1:0>);
```

## Library pseudocode for aarch64/functions/sve/MemNF

```
// MemNF[] - non-assignment form
// =====

(bits(8*size), boolean) MemNF(bits(64) address, integer size, AccType acctype]
    assert size IN {1, 2, 4, 8, 16};
    bits(8*size) value;

    aligned = (address == Align(address, size));
    A = SCTLR[].A;

    if !aligned && (A == '1') then
        return (bits(8*size) UNKNOWN, TRUE);

    atomic = aligned || size == 1;

    if !atomic then
        (value<7:0>, bad) = MemSingleNF[address, 1, acctype, aligned];

        if bad then
            return (bits(8*size) UNKNOWN, TRUE);

        // For subsequent bytes it is CONSTRAINED UNPREDICTABLE whether an unaligned Device memory
        // access will generate an Alignment Fault, as to get this far means the first byte did
        // not, so we must be changing to a new translation page.
        if !aligned then
            c = ConstrainUnpredictable(Unpredictable\_DEVPAGE2);
            assert c IN {Constraint\_FAULT, Constraint\_NONE};
            if c == Constraint\_NONE then aligned = TRUE;

        for i = 1 to size-1
            (value<8*i+7:8*i>, bad) = MemSingleNF[address+i, 1, acctype, aligned];

            if bad then
                return (bits(8*size) UNKNOWN, TRUE);
    else
        (value, bad) = MemSingleNF[address, size, acctype, aligned];
        if bad then
            return (bits(8*size) UNKNOWN, TRUE);

    if BigEndian(acctype) then
        value = BigEndianReverse(value);

    return (value, FALSE);
```

## Library pseudocode for aarch64/functions/sve/MemSingleNF

```
// MemSingleNF[] - non-assignment form
// =====

(bits(8*size), boolean) MemSingleNF(bits(64) address, integer size, AccType acctype, boolean aligned]
    bits(8*size) value;
    boolean iswrite = FALSE;
    AddressDescriptor memaddrdesc;

    // Implementation may suppress NF load for any reason
    if ConstrainUnpredictableBool(Unpredictable\_NONFAULT) then
        return (bits(8*size) UNKNOWN, TRUE);

    // MMU or MPU
    memaddrdesc = AArch64.TranslateAddress(address, acctype, iswrite, aligned, size);

    // Non-fault load from Device memory must not be performed externally
    if memaddrdesc.memattrs.memtype == MemType\_Device then
        return (bits(8*size) UNKNOWN, TRUE);

    // Check for aborts or debug exceptions
    if IsFault(memaddrdesc) then
        return (bits(8*size) UNKNOWN, TRUE);

    // Memory array access
    accdesc = CreateAccessDescriptor(acctype);
    if HaveMTE2Ext() then
        if AArch64.AccessIsTagChecked(address, acctype) then
            bits(4) ptag = AArch64.PhysicalTag(address);
            if !AArch64.CheckTag(memaddrdesc, ptag, iswrite) then
                return (bits(8*size) UNKNOWN, TRUE);
        value = _Mem[memaddrdesc, size, accdesc, iswrite];

    return (value, FALSE);
```

## Library pseudocode for aarch64/functions/sve/NoneActive

```
// NoneActive()
// =====

bit NoneActive(bits(N) mask, bits(N) x, integer esize)
    integer elements = N DIV (esize DIV 8);
    for e = 0 to elements-1
        if ElemP[mask, e, esize] == '1' && ElemP[x, e, esize] == '1' then return '0';
    return '1';
```

## Library pseudocode for aarch64/functions/sve/P

```
// P[] - non-assignment form
// =====

bits(width) P[integer n]
    assert n >= 0 && n <= 31;
    assert width == PL;
    return _P[n]<width-1:0>;

// P[] - assignment form
// =====

P[integer n] = bits(width) value
    assert n >= 0 && n <= 31;
    assert width == PL;
    if ConstrainUnpredictableBool(Unpredictable\_SVEZERoupper) then
        _P[n] = ZeroExtend(value);
    else
        _P[n]<width-1:0> = value;
```



## Library pseudocode for aarch64/functions/sve/PL

```
// PL - non-assignment form
// =====

integer PL
  return VL DIV 8;
```

## Library pseudocode for aarch64/functions/sve/PredTest

```
// PredTest()
// =====

bits(4) PredTest(bits(N) mask, bits(N) result, integer esize)
  bit n = FirstActive(mask, result, esize);
  bit z = NoneActive(mask, result, esize);
  bit c = NOT LastActive(mask, result, esize);
  bit v = '0';
  return n:z:c:v;
```

## Library pseudocode for aarch64/functions/sve/ReducePredicated

```
// ReducePredicated()
// =====

bits(esize) ReducePredicated(ReduceOp op, bits(N) input, bits(M) mask, bits(esize) identity)
  assert(N == M * 8);
  integer p2bits = CeilPow2(N);
  bits(p2bits) operand;
  integer elements = p2bits DIV esize;

  for e = 0 to elements-1
    if e * esize < N && ElemP[mask, e, esize] == '1' then
      Elem[operand, e, esize] = Elem[input, e, esize];
    else
      Elem[operand, e, esize] = identity;

  return Reduce(op, operand, esize);
```

## Library pseudocode for aarch64/functions/sve/Reverse

```
// Reverse()
// =====
// Reverse subwords of M bits in an N-bit word

bits(N) Reverse(bits(N) word, integer M)
  bits(N) result;
  integer sw = N DIV M;
  assert N == sw * M;
  for s = 0 to sw-1
    Elem[result, sw - 1 - s, M] = Elem[word, s, M];
  return result;
```

## Library pseudocode for aarch64/functions/sve/SVEAccessTrap

```
// SVEAccessTrap()
// =====
// Trapped access to SVE registers due to CPACR_EL1, CPTR_EL2, or CPTR_EL3.

SVEAccessTrap(bits(2) target_el)
    assert UInt(target_el) >= UInt(PSTATE.EL) && target_el != EL0 && HaveEL(target_el);
    route_to_el2 = target_el == EL1 && EL2Enabled() && HCR_EL2.TGE == '1';

    exception = ExceptionSyndrome(Exception_SVEAccessTrap);
    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x0;

    if route_to_el2 then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(target_el, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/functions/sve/SVECmp

```
enumeration SVECmp { Cmp_EQ, Cmp_NE, Cmp_GE, Cmp_GT, Cmp_LT, Cmp_LE, Cmp_UN };
```

## Library pseudocode for aarch64/functions/sve/SVEMoveMaskPreferred

```
// SVEMoveMaskPreferred()
// =====
// Return FALSE if a bitmask immediate encoding would generate an immediate
// value that could also be represented by a single DUP instruction.
// Used as a condition for the preferred MOV<-DUPM> alias.

boolean SVEMoveMaskPreferred(bits(13) imm13)
    bits(64) imm;
    (imm, -) = DecodeBitMasks(imm13<12>, imm13<5:0>, imm13<11:6>, TRUE);

    // Check for 8 bit immediates
    if !IsZero(imm<7:0>) then
        // Check for 'ffffffffffffxy' or '00000000000000xy'
        if IsZero(imm<63:7>) || IsOnes(imm<63:7>) then
            return FALSE;

        // Check for 'ffffffxyffffffxy' or '000000xy000000xy'
        if imm<63:32> == imm<31:0> && (IsZero(imm<31:7>) || IsOnes(imm<31:7>)) then
            return FALSE;

        // Check for 'ffxyffxyffxyffxy' or '00xy00xy00xy00xy'
        if imm<63:32> == imm<31:0> && imm<31:16> == imm<15:0> && (IsZero(imm<15:7>) || IsOnes(imm<15:7>)) then
            return FALSE;

        // Check for 'xyxyxyxyxyxyxyxy'
        if imm<63:32> == imm<31:0> && imm<31:16> == imm<15:0> && (imm<15:8> == imm<7:0>) then
            return FALSE;

    // Check for 16 bit immediates
    else
        // Check for 'ffffffffffffxy00' or '000000000000xy00'
        if IsZero(imm<63:15>) || IsOnes(imm<63:15>) then
            return FALSE;

        // Check for 'ffffxy00ffffxy00' or '0000xy000000xy00'
        if imm<63:32> == imm<31:0> && (IsZero(imm<31:7>) || IsOnes(imm<31:7>)) then
            return FALSE;

        // Check for 'xy00xy00xy00xy00'
        if imm<63:32> == imm<31:0> && imm<31:16> == imm<15:0> then
            return FALSE;

    return TRUE;
```

## Library pseudocode for aarch64/functions/sve/System

```
constant integer MAX_VL = 2048;
constant integer MAX_PL = 256;
array bits(MAX_VL) _Z[0..31];
array bits(MAX_PL) _P[0..15];
bits(MAX_PL) _FFR;
```

## Library pseudocode for aarch64/functions/sve/VL

```
// VL - non-assignment form
// =====

integer VL
integer vl;

if PSTATE.EL == EL1 || (PSTATE.EL == EL0 && !IsInHost()) then
    vl = UInt(ZCR_EL1.LEN);

if PSTATE.EL == EL2 || (PSTATE.EL == EL0 && IsInHost()) then
    vl = UInt(ZCR_EL2.LEN);
elsif PSTATE.EL IN {EL0, EL1} && EL2Enabled() then
    vl = Min(vl, UInt(ZCR_EL2.LEN));

if PSTATE.EL == EL3 then
    vl = UInt(ZCR_EL3.LEN);
elsif HaveEL(EL3) then
    vl = Min(vl, UInt(ZCR_EL3.LEN));

vl = (vl + 1) * 128;
vl = ImplementedSVEVectorLength(vl);

return vl;
```

## Library pseudocode for aarch64/functions/sve/Z

```
// Z[] - non-assignment form
// =====

bits(width) Z[integer n]
assert n >= 0 && n <= 31;
assert width == VL;
return _Z[n]<width-1:0>;

// Z[] - assignment form
// =====

Z[integer n] = bits(width) value
assert n >= 0 && n <= 31;
assert width == VL;
if ConstrainUnpredictableBool(Unpredictable_SVEZEROUPPER) then
    _Z[n] = ZeroExtend(value);
else
    _Z[n]<width-1:0> = value;
```

## Library pseudocode for aarch64/functions/sysregisters/CNTKCTL

```
// CNTKCTL[] - non-assignment form
// =====

CNTKCTLType CNTKCTL[]
bits(64) r;
if IsInHost() then
    r = CNTKCTL_EL2;
    return r;
r = CNTKCTL_EL1;
return r;
```

## Library pseudocode for aarch64/functions/sysregisters/CNTKCTLType

```
type CNTKCTLType;
```

## Library pseudocode for aarch64/functions/sysregisters/CPACR

```
// CPACR[] - non-assignment form
// =====

CPACRType CPACR[]
  bits(64) r;
  if IsInHost\(\) then
    r = CPTR_EL2;
    return r;
  r = CPACR_EL1;
  return r;
```

## Library pseudocode for aarch64/functions/sysregisters/CPACRType

```
type CPACRType;
```

## Library pseudocode for aarch64/functions/sysregisters/ELR

```
// ELR[] - non-assignment form
// =====

bits(64) ELR[bits(2) el]
  bits(64) r;
  case el of
    when EL1  r = ELR_EL1;
    when EL2  r = ELR_EL2;
    when EL3  r = ELR_EL3;
    otherwise Unreachable\(\);
  return r;

// ELR[] - non-assignment form
// =====

bits(64) ELR[]
  assert PSTATE.EL != EL0;
  return ELR[PSTATE.EL];

// ELR[] - assignment form
// =====

ELR[bits(2) el] = bits(64) value
  bits(64) r = value;
  case el of
    when EL1  ELR_EL1 = r;
    when EL2  ELR_EL2 = r;
    when EL3  ELR_EL3 = r;
    otherwise Unreachable\(\);
  return;

// ELR[] - assignment form
// =====

ELR[] = bits(64) value
  assert PSTATE.EL != EL0;
  ELR[PSTATE.EL] = value;
  return;
```

## Library pseudocode for aarch64/functions/sysregisters/ESR

```
// ESR[] - non-assignment form
// =====

ESRType ESR[bits(2) regime]
    bits(64) r;
    case regime of
        when EL1    r = ESR_EL1;
        when EL2    r = ESR_EL2;
        when EL3    r = ESR_EL3;
        otherwise Unreachable\(\);
    return r;

// ESR[] - non-assignment form
// =====

ESRType ESR[]
    return ESR\[S1TranslationRegime\\(\\)\];

// ESR[] - assignment form
// =====

ESR[bits(2) regime] = ESRType value
    bits(64) r = value;
    case regime of
        when EL1    ESR_EL1 = r;
        when EL2    ESR_EL2 = r;
        when EL3    ESR_EL3 = r;
        otherwise Unreachable\(\);
    return;

// ESR[] - assignment form
// =====

ESR[] = ESRType value
    ESR\[S1TranslationRegime\\(\\)\] = value;
```

## Library pseudocode for aarch64/functions/sysregisters/ESRType

```
type ESRType;
```

## Library pseudocode for aarch64/functions/sysregisters/FAR

```
// FAR[] - non-assignment form
// =====

bits(64) FAR[bits(2) regime]
  bits(64) r;
  case regime of
    when EL1   r = FAR_EL1;
    when EL2   r = FAR_EL2;
    when EL3   r = FAR_EL3;
    otherwise Unreachable\(\);
  return r;

// FAR[] - non-assignment form
// =====

bits(64) FAR[]
  return FAR\[S1TranslationRegime\(\)\];

// FAR[] - assignment form
// =====

FAR[bits(2) regime] = bits(64) value
  bits(64) r = value;
  case regime of
    when EL1   FAR_EL1 = r;
    when EL2   FAR_EL2 = r;
    when EL3   FAR_EL3 = r;
    otherwise Unreachable\(\);
  return;

// FAR[] - assignment form
// =====

FAR[] = bits(64) value
  FAR\[S1TranslationRegime\(\)\] = value;
  return;
```

## Library pseudocode for aarch64/functions/sysregisters/MAIR

```
// MAIR[] - non-assignment form
// =====

MAIRType MAIR[bits(2) regime]
  bits(64) r;
  case regime of
    when EL1   r = MAIR_EL1;
    when EL2   r = MAIR_EL2;
    when EL3   r = MAIR_EL3;
    otherwise Unreachable\(\);
  return r;

// MAIR[] - non-assignment form
// =====

MAIRType MAIR[]
  return MAIR\[S1TranslationRegime\(\)\];
```

## Library pseudocode for aarch64/functions/sysregisters/MAIRType

```
type MAIRType;
```

## Library pseudocode for aarch64/functions/sysregisters/SCTLR

```
// SCTLR[] - non-assignment form
// =====

SCTLRType SCTLR[bits(2) regime]
    bits(64) r;
    case regime of
        when EL1 r = SCTLR_EL1;
        when EL2 r = SCTLR_EL2;
        when EL3 r = SCTLR_EL3;
        otherwise Unreachable\(\);
    return r;

// SCTLR[] - non-assignment form
// =====

SCTLRType SCTLR[]
    return SCTLR\[S1TranslationRegime\(\)\];
```

## Library pseudocode for aarch64/functions/sysregisters/SCTLRType

```
type SCTLRType;
```

## Library pseudocode for aarch64/functions/sysregisters/VBAR

```
// VBAR[] - non-assignment form
// =====

bits(64) VBAR[bits(2) regime]
    bits(64) r;
    case regime of
        when EL1 r = VBAR_EL1;
        when EL2 r = VBAR_EL2;
        when EL3 r = VBAR_EL3;
        otherwise Unreachable\(\);
    return r;

// VBAR[] - non-assignment form
// =====

bits(64) VBAR[]
    return VBAR\[S1TranslationRegime\(\)\];
```

## Library pseudocode for aarch64/functions/system/AArch64.AllocationTagAccessIsEnabled

```
// AArch64.AllocationTagAccessIsEnabled()
// =====
// Check whether access to Allocation Tags is enabled.

boolean AArch64.AllocationTagAccessIsEnabled(AccType acctype)
    bits(2) el = AArch64.AccessUsesEL(acctype);

    if SCR_EL3.ATA == '0' && el IN {EL0, EL1, EL2} then
        return FALSE;
    elsif HCR_EL2.ATA == '0' && el IN {EL0, EL1} && EL2Enabled() && HCR_EL2.<E2H,TGE> != '11' then
        return FALSE;
    elsif SCTLR_EL3.ATA == '0' && el == EL3 then
        return FALSE;
    elsif SCTLR_EL2.ATA == '0' && el == EL2 then
        return FALSE;
    elsif SCTLR_EL1.ATA == '0' && el == EL1 then
        return FALSE;
    elsif SCTLR_EL2.ATA0 == '0' && el == EL0 && EL2Enabled() && HCR_EL2.<E2H,TGE> == '11' then
        return FALSE;
    elsif SCTLR_EL1.ATA0 == '0' && el == EL0 && !(EL2Enabled() && HCR_EL2.<E2H,TGE> == '11') then
        return FALSE;
    else
        return TRUE;
```

## Library pseudocode for aarch64/functions/system/AArch64.ChooseNonExcludedTag

```
// AArch64.ChooseNonExcludedTag()
// =====
// Return a tag derived from the start and the offset values, excluding
// any tags in the given mask.

bits(4) AArch64.ChooseNonExcludedTag(bits(4) tag, bits(4) offset, bits(16) exclude)
    if IsOnes(exclude) then
        return '0000';

    if offset == '0000' then
        while exclude<UInt(tag)> == '1' do
            tag = tag + '0001';

    while offset != '0000' do
        offset = offset - '0001';
        tag = tag + '0001';
        while exclude<UInt(tag)> == '1' do
            tag = tag + '0001';

    return tag;
```

## Library pseudocode for aarch64/functions/system/AArch64.ExecutingBROrBLROrRetInstr

```
// AArch64.ExecutingBROrBLROrRetInstr()
// =====
// Returns TRUE if current instruction is a BR, BLR, RET, B[L]RA[B][Z], or RETA[B].

boolean AArch64.ExecutingBROrBLROrRetInstr()
    if !HaveBTIExt() then return FALSE;

    instr = ThisInstr();
    if instr<31:25> == '1101011' && instr<20:16> == '11111' then
        opc = instr<24:21>;
        return opc != '0101';
    else
        return FALSE;
```



### Library pseudocode for aarch64/functions/system/AArch64.ExecutingBTIInstr

```
// AArch64.ExecutingBTIInstr()
// =====
// Returns TRUE if current instruction is a BTI.

boolean AArch64.ExecutingBTIInstr()
    if !HaveBTIExt() then return FALSE;

    instr = ThisInstr();
    if instr<31:22> == '1101010100' && instr<21:12> == '0000110010' && instr<4:0> == '11111' then
        CRm = instr<11:8>;
        op2 = instr<7:5>;
        return (CRm == '0100' && op2<0> == '0');
    else
        return FALSE;
```

### Library pseudocode for aarch64/functions/system/AArch64.ExecutingERETInstr

```
// AArch64.ExecutingERETInstr()
// =====
// Returns TRUE if current instruction is ERET.

boolean AArch64.ExecutingERETInstr()
    instr = ThisInstr();
    return instr<31:12> == '11010110100111110000';
```

### Library pseudocode for aarch64/functions/system/AArch64.NextRandomTagBit

```
// AArch64.NextRandomTagBit()
// =====
// Generate a random bit suitable for generating a random Allocation Tag.

bit AArch64.NextRandomTagBit()
    bits(16) lfsr = RGSr_EL1.SEED;
    bit top = lfsr<5> EOR lfsr<3> EOR lfsr<2> EOR lfsr<0>;
    RGSr_EL1.SEED = top:lfsr<15:1>;
    return top;
```

### Library pseudocode for aarch64/functions/system/AArch64.RandomTag

```
// AArch64.RandomTag()
// =====
// Generate a random Allocation Tag.

bits(4) AArch64.RandomTag()
    bits(4) tag;
    for i = 0 to 3
        tag<i> = AArch64.NextRandomTagBit();
    return tag;
```

### Library pseudocode for aarch64/functions/system/AArch64.SysInstr

```
// Execute a system instruction with write (source operand).
AArch64.SysInstr(integer op0, integer op1, integer crn, integer crm, integer op2, bits(64) val);
```

### Library pseudocode for aarch64/functions/system/AArch64.SysInstrWithResult

```
// Execute a system instruction with read (result operand).
// Returns the result of the instruction.
bits(64) AArch64.SysInstrWithResult(integer op0, integer op1, integer crn, integer crm, integer op2);
```

### Library pseudocode for aarch64/functions/system/AArch64.SysRegRead

```
// Read from a system register and return the contents of the register.
bits(64) AArch64.SysRegRead(integer op0, integer op1, integer crn, integer crm, integer op2);
```

### Library pseudocode for aarch64/functions/system/AArch64.SysRegWrite

```
// Write to a system register.
AArch64.SysRegWrite(integer op0, integer op1, integer crn, integer crm, integer op2, bits(64) val);
```

### Library pseudocode for aarch64/functions/system/BTypeCompatible

```
boolean BTypeCompatible;
```

### Library pseudocode for aarch64/functions/system/BTypeCompatible\_BTI

```
// BTypeCompatible_BTI
// =====
// This function determines whether a given hint encoding is compatible with the current value of
// PSTATE.BTYPE. A value of TRUE here indicates a valid Branch Target Identification instruction.

boolean BTypeCompatible_BTI(bits(2) hintcode)
    case hintcode of
        when '00'
            return FALSE;
        when '01'
            return PSTATE.BTYPE != '11';
        when '10'
            return PSTATE.BTYPE != '10';
        when '11'
            return TRUE;
```

### Library pseudocode for aarch64/functions/system/BTypeCompatible\_PACIXSP

```
// BTypeCompatible_PACIXSP()
// =====
// Returns TRUE if PACIASP, PACIBSP instruction is implicit compatible with PSTATE.BTYPE,
// FALSE otherwise.

boolean BTypeCompatible_PACIXSP()
    if PSTATE.BTYPE IN {'01', '10'} then
        return TRUE;
    elsif PSTATE.BTYPE == '11' then
        index = if PSTATE.EL == EL0 then 35 else 36;
        return SCTLR[]<index> == '0';
    else
        return FALSE;
```

### Library pseudocode for aarch64/functions/system/BTypeNext

```
bits(2) BTypeNext;
```

### Library pseudocode for aarch64/functions/system/ChooseRandomNonExcludedTag

```
// The ChooseRandomNonExcludedTag function is used when GCR_EL1.RRND == '1' to generate random
// Allocation Tags.
//
// The resulting Allocation Tag is selected from the set [0,15], excluding any Allocation Tag where
// exclude[tag_value] == 1. If 'exclude' is all Ones, the returned Allocation Tag is '0000'.
//
// This function is permitted to generate a non-deterministic selection from the set of non-excluded
// Allocation Tags. A reasonable implementation is described by the Pseudocode used when
// GCR_EL1.RRND is 0, but with a non-deterministic implementation of NextRandomTagBit(). Implementations
// may choose to behave the same as GCR_EL1.RRND=0.
bits(4) ChooseRandomNonExcludedTag(bits(16) exclude);
```

## Library pseudocode for aarch64/functions/system/InGuardedPage

```
boolean InGuardedPage;
```

## Library pseudocode for aarch64/functions/system/IsHCRXEL2Enabled

```
// IsHCRXEL2Enabled()
// =====
// Returns TRUE if access to HCRX_EL2 register is enabled, and FALSE otherwise.
// Indirect read of HCRX_EL2 returns 0 when access is not enabled.

boolean IsHCRXEL2Enabled()
    assert(HaveFeatHCX());
    if HaveEL(EL3) && SCR_EL3.HXEn == '0' then
        return FALSE;

    return EL2Enabled();
```

## Library pseudocode for aarch64/functions/system/SetBTypeCompatible

```
// SetBTypeCompatible()
// =====
// Sets the value of BTypeCompatible global variable used by BTI

SetBTypeCompatible(boolean x)
    BTypeCompatible = x;
```

## Library pseudocode for aarch64/functions/system/SetBTypeNext

```
// SetBTypeNext()
// =====
// Set the value of BTypeNext global variable used by BTI

SetBTypeNext(bits(2) x)
    BTypeNext = x;
```

## Library pseudocode for aarch64/functions/system/SetInGuardedPage

```
// SetInGuardedPage()
// =====
// Global state updated to denote if memory access is from a guarded page.

SetInGuardedPage(boolean guardedpage)
    InGuardedPage = guardedpage;
```

## Library pseudocode for aarch64/instrs/branch/eret/AArch64.ExceptionReturn

```
// AArch64.ExceptionReturn()
// =====

AArch64.ExceptionReturn(bits(64) new_pc, bits(64) spsr)

    if HaveIESB() then
        sync_errors = SCTLRL[0].IESB == '1';
        if HaveDoubleFaultExt() then
            sync_errors = sync_errors || (SCR_EL3.<EA,NMEA> == '11' && PSTATE.EL == EL3);
        if sync_errors then
            SynchronizeErrors();
            iesb_req = TRUE;
            TakeUnmaskedPhysicalSErrorInterrupts(iesb_req);
        SynchronizeContext();

    // Attempts to change to an illegal state will invoke the Illegal Execution state mechanism
    bits(2) source_el = PSTATE.EL;
    SetPSTATEFromPSR(spsr);
    ClearExclusiveLocal(ProcessorID());
    SendEventLocal();

    if PSTATE.IL == '1' && spsr<4> == '1' && spsr<20> == '0' then
        // If the exception return is illegal, PC[63:32,1:0] are UNKNOWN
        new_pc<63:32> = bits(32) UNKNOWN;
        new_pc<1:0> = bits(2) UNKNOWN;
    elseif UsingAArch32() then // Return to AArch32
        // ELR_ELx[1:0] or ELR_ELx[0] are treated as being 0, depending on the target instruction set state
        if PSTATE.T == '1' then
            new_pc<0> = '0'; // T32
        else
            new_pc<1:0> = '00'; // A32
    else // Return to AArch64
        // ELR_ELx[63:56] might include a tag
        new_pc = AArch64.BranchAddr(new_pc);

    if UsingAArch32() then
        // 32 most significant bits are ignored.
        boolean branch_conditional = FALSE;
        BranchTo(new_pc<31:0>, BranchType_ERET, branch_conditional);
    else
        BranchToAddr(new_pc, BranchType_ERET);
```

## Library pseudocode for aarch64/instrs/countop/CountOp

```
enumeration CountOp {CountOp_CLZ, CountOp_CLS, CountOp_CNT};
```

## Library pseudocode for aarch64/instrs/extendreg/DecodeRegExtend

```
// DecodeRegExtend()
// =====
// Decode a register extension option

ExtendType DecodeRegExtend(bits(3) op)
    case op of
        when '000' return ExtendType_UXTB;
        when '001' return ExtendType_UXTH;
        when '010' return ExtendType_UXTW;
        when '011' return ExtendType_UXTX;
        when '100' return ExtendType_SXTB;
        when '101' return ExtendType_SXTH;
        when '110' return ExtendType_SXTW;
        when '111' return ExtendType_SXTX;
```

## Library pseudocode for aarch64/instrs/extendreg/ExtendReg

```
// ExtendReg()
// =====
// Perform a register extension and shift

bits(N) ExtendReg(integer reg, ExtendType exttype, integer shift)
    assert shift >= 0 && shift <= 4;
    bits(N) val = X[reg];
    boolean unsigned;
    integer len;

    case exttype of
        when ExtendType_SXTB unsigned = FALSE; len = 8;
        when ExtendType_SXTH unsigned = FALSE; len = 16;
        when ExtendType_SXTW unsigned = FALSE; len = 32;
        when ExtendType_SCTX unsigned = FALSE; len = 64;
        when ExtendType_UXTB unsigned = TRUE; len = 8;
        when ExtendType_UXTH unsigned = TRUE; len = 16;
        when ExtendType_UXTW unsigned = TRUE; len = 32;
        when ExtendType_UCTX unsigned = TRUE; len = 64;

    // Note the extended width of the intermediate value and
    // that sign extension occurs from bit <len+shift-1>, not
    // from bit <len-1>. This is equivalent to the instruction
    // [SU]BFIZ Rtmp, Rreg, #shift, #len
    // It may also be seen as a sign/zero extend followed by a shift:
    // LSL(Extend(val<len-1:0>, N, unsigned), shift);

    len = Min(len, N - shift);
    return Extend(val<len-1:0> : Zeros(shift), N, unsigned);
```

## Library pseudocode for aarch64/instrs/extendreg/ExtendType

```
enumeration ExtendType {ExtendType_SXTB, ExtendType_SXTH, ExtendType_SXTW, ExtendType_SCTX,
                        ExtendType_UXTB, ExtendType_UXTH, ExtendType_UXTW, ExtendType_UCTX};
```

## Library pseudocode for aarch64/instrs/float/arithmetic/max-min/fpmaxminop/FPMaxMinOp

```
enumeration FPMaxMinOp {FPMaxMinOp_MAX, FPMaxMinOp_MIN,
                        FPMaxMinOp_MAXNUM, FPMaxMinOp_MINNUM};
```

## Library pseudocode for aarch64/instrs/float/arithmetic/unary/fpunaryop/FPUnaryOp

```
enumeration FPUnaryOp {FPUnaryOp_ABS, FPUnaryOp_MOV,
                       FPUnaryOp_NEG, FPUnaryOp_SQRT};
```

## Library pseudocode for aarch64/instrs/float/convert/fpconvop/FPConvOp

```
enumeration FPConvOp {FPConvOp_CVT_FtoI, FPConvOp_CVT_ItoF,
                      FPConvOp_MOV_FtoI, FPConvOp_MOV_ItoF,
                      , FPConvOp_CVT_FtoI_JS
};
```

## Library pseudocode for aarch64/instrs/integer/bitfield/bfxpreferred/BFXPreferred

```
// BFXPreferred()
// =====
//
// Return TRUE if UBFX or SBFX is the preferred disassembly of a
// UBFM or SBFM bitfield instruction. Must exclude more specific
// aliases UBFIZ, SBFIZ, UXT[BH], SXT[BHW], LSL, LSR and ASR.

boolean BFXPreferred(bit sf, bit uns, bits(6) imms, bits(6) immr)
    integer S = UInt(imms);
    integer R = UInt(immr);

    // must not match UBFIZ/SBFIX alias
    if UInt(imms) < UInt(immr) then
        return FALSE;

    // must not match LSR/ASR/LSL alias (imms == 31 or 63)
    if imms == sf:'11111' then
        return FALSE;

    // must not match UXTx/SXTx alias
    if immr == '000000' then
        // must not match 32-bit UXT[BH] or SXT[BH]
        if sf == '0' && imms IN {'000111', '001111'} then
            return FALSE;
        // must not match 64-bit SXT[BHW]
        if sf:uns == '10' && imms IN {'000111', '001111', '011111'} then
            return FALSE;

    // must be UBFX/SBFX alias
    return TRUE;
```



```

// DecodeBitMasks()
// =====

// Decode AArch64 bitfield and logical immediate masks which use a similar encoding structure

(bits(M), bits(M)) DecodeBitMasks(bit immN, bits(6) imms, bits(6) immr, boolean immediate)
    bits(64) tmask, wmask;
    bits(6) tmask_and, wmask_and;
    bits(6) tmask_or, wmask_or;
    bits(6) levels;

    // Compute log2 of element size
    // 2^len must be in range [2, M]
    len = HighestSetBit(immN:NOT(imms));
    if len < 1 then UNDEFINED;
    assert M >= (1 << len);

    // Determine S, R and S - R parameters
    levels = ZeroExtend(Ones(len), 6);

    // For logical immediates an all-ones value of S is reserved
    // since it would generate a useless all-ones result (many times)
    if immediate && (imms AND levels) == levels then
        UNDEFINED;

    S = UInt(imms AND levels);
    R = UInt(immr AND levels);
    diff = S - R;    // 6-bit subtract with borrow

    // From a software perspective, the remaining code is equivalent to:
    //   esize = 1 << len;
    //   d = UInt(diff<len-1:0>);
    //   welem = ZeroExtend(Ones(S + 1), esize);
    //   telem = ZeroExtend(Ones(d + 1), esize);
    //   wmask = Replicate(ROR(welem, R));
    //   tmask = Replicate(telem);
    //   return (wmask, tmask);

    // Compute "top mask"
    tmask_and = diff<5:0> OR NOT(levels);
    tmask_or = diff<5:0> AND levels;

    tmask = Ones(64);
    tmask = ((tmask
        AND Replicate(Replicate(tmask_and<0>, 1) : Ones(1), 32))
        OR Replicate(Zeros(1) : Replicate(tmask_or<0>, 1), 32));
    // optimization of first step:
    // tmask = Replicate(tmask_and<0> : '1', 32);
    tmask = ((tmask
        AND Replicate(Replicate(tmask_and<1>, 2) : Ones(2), 16))
        OR Replicate(Zeros(2) : Replicate(tmask_or<1>, 2), 16));
    tmask = ((tmask
        AND Replicate(Replicate(tmask_and<2>, 4) : Ones(4), 8))
        OR Replicate(Zeros(4) : Replicate(tmask_or<2>, 4), 8));
    tmask = ((tmask
        AND Replicate(Replicate(tmask_and<3>, 8) : Ones(8), 4))
        OR Replicate(Zeros(8) : Replicate(tmask_or<3>, 8), 4));
    tmask = ((tmask
        AND Replicate(Replicate(tmask_and<4>, 16) : Ones(16), 2))
        OR Replicate(Zeros(16) : Replicate(tmask_or<4>, 16), 2));
    tmask = ((tmask
        AND Replicate(Replicate(tmask_and<5>, 32) : Ones(32), 1))
        OR Replicate(Zeros(32) : Replicate(tmask_or<5>, 32), 1));

    // Compute "wraparound mask"
    wmask_and = immr OR NOT(levels);
    wmask_or = immr AND levels;

    wmask = Zeros(64);
    wmask = ((wmask

```



```

        AND Replicate(Ones(1) : Replicate(wmask_and<0>, 1), 32))
        OR Replicate(Replicate(wmask_or<0>, 1) : Zeros(1), 32));
// optimization of first step:
// wmask = Replicate(wmask_or<0> : '0', 32);
wmask = ((wmask
        AND Replicate(Ones(2) : Replicate(wmask_and<1>, 2), 16))
        OR Replicate(Replicate(wmask_or<1>, 2) : Zeros(2), 16));
wmask = ((wmask
        AND Replicate(Ones(4) : Replicate(wmask_and<2>, 4), 8))
        OR Replicate(Replicate(wmask_or<2>, 4) : Zeros(4), 8));
wmask = ((wmask
        AND Replicate(Ones(8) : Replicate(wmask_and<3>, 8), 4))
        OR Replicate(Replicate(wmask_or<3>, 8) : Zeros(8), 4));
wmask = ((wmask
        AND Replicate(Ones(16) : Replicate(wmask_and<4>, 16), 2))
        OR Replicate(Replicate(wmask_or<4>, 16) : Zeros(16), 2));
wmask = ((wmask
        AND Replicate(Ones(32) : Replicate(wmask_and<5>, 32), 1))
        OR Replicate(Replicate(wmask_or<5>, 32) : Zeros(32), 1));

if diff<6> != '0' then // borrow from S - R
    wmask = wmask AND tmask;
else
    wmask = wmask OR tmask;

return (wmask<M-1:0>, tmask<M-1:0>);

```

### Library pseudocode for aarch64/instrs/integer/ins-ext/insert/movewide/movewideop/MoveWideOp

```

enumeration MoveWideOp {MoveWideOp_N, MoveWideOp_Z, MoveWideOp_K};

```

### Library pseudocode for aarch64/instrs/integer/logical/movwpreferred/MoveWidePreferred

```

// MoveWidePreferred()
// =====
//
// Return TRUE if a bitmask immediate encoding would generate an immediate
// value that could also be represented by a single MOVZ or MOVN instruction.
// Used as a condition for the preferred MOV<-ORR alias.

boolean MoveWidePreferred(bit sf, bit immN, bits(6) imms, bits(6) immr)
    integer S = UInt(imms);
    integer R = UInt(immr);
    integer width = if sf == '1' then 64 else 32;

    // element size must equal total immediate size
    if sf == '1' && immN:imms != 'lxxxxxx' then
        return FALSE;
    if sf == '0' && immN:imms != '00xxxxx' then
        return FALSE;

    // for MOVZ must contain no more than 16 ones
    if S < 16 then
        // ones must not span halfword boundary when rotated
        return (-R MOD 16) <= (15 - S);

    // for MOVN must contain no more than 16 zeros
    if S >= width - 15 then
        // zeros must not span halfword boundary when rotated
        return (R MOD 16) <= (S - (width - 15));

    return FALSE;

```

## Library pseudocode for aarch64/instrs/integer/shiftreg/DecodeShift

```
// DecodeShift()
// =====
// Decode shift encodings

ShiftType DecodeShift(bits(2) op)
    case op of
        when '00' return ShiftType_LSL;
        when '01' return ShiftType_LSR;
        when '10' return ShiftType_ASR;
        when '11' return ShiftType_ROR;
```

## Library pseudocode for aarch64/instrs/integer/shiftreg/ShiftReg

```
// ShiftReg()
// =====
// Perform shift of a register operand

bits(N) ShiftReg(integer reg, ShiftType shifttype, integer amount)
    bits(N) result = X[reg];
    case shifttype of
        when ShiftType_LSL result = LSL(result, amount);
        when ShiftType_LSR result = LSR(result, amount);
        when ShiftType_ASR result = ASR(result, amount);
        when ShiftType_ROR result = ROR(result, amount);
    return result;
```

## Library pseudocode for aarch64/instrs/integer/shiftreg/ShiftType

```
enumeration ShiftType {ShiftType_LSL, ShiftType_LSR, ShiftType_ASR, ShiftType_ROR};
```

## Library pseudocode for aarch64/instrs/logicalop/LogicalOp

```
enumeration LogicalOp {LogicalOp_AND, LogicalOp_EOR, LogicalOp_ORR};
```

## Library pseudocode for aarch64/instrs/memory/memop/MemAtomicOp

```
enumeration MemAtomicOp {MemAtomicOp_ADD,
    MemAtomicOp_BIC,
    MemAtomicOp_EOR,
    MemAtomicOp_ORR,
    MemAtomicOp_SMAX,
    MemAtomicOp_SMIN,
    MemAtomicOp_UMAX,
    MemAtomicOp_UMIN,
    MemAtomicOp_SWP};
```

## Library pseudocode for aarch64/instrs/memory/memop/MemOp

```
enumeration MemOp {MemOp_LOAD, MemOp_STORE, MemOp_PREFETCH};
```

## Library pseudocode for aarch64/instrs/memory/prefetch/Prefetch

```
// Prefetch()
// =====

// Decode and execute the prefetch hint on ADDRESS specified by PRFOP

Prefetch(bits(64) address, bits(5) prfop)
    PrefetchHint hint;
    integer target;
    boolean stream;

    case prfop<4:3> of
        when '00' hint = Prefetch_READ;           // PLD: prefetch for load
        when '01' hint = Prefetch_EXEC;           // PLI: preload instructions
        when '10' hint = Prefetch_WRITE;          // PST: prepare for store
        when '11' return;                          // unallocated hint
    target = UInt(prfop<2:1>);                      // target cache level
    stream = (prfop<0> != '0');                    // streaming (non-temporal)
    Hint_Prefetch(address, hint, target, stream);
    return;
```

## Library pseudocode for aarch64/instrs/system/barriers/barrierop/MemBarrierOp

```
enumeration MemBarrierOp { MemBarrierOp_DSB      // Data Synchronization Barrier
                           , MemBarrierOp_DMB      // Data Memory Barrier
                           , MemBarrierOp_ISB      // Instruction Synchronization Barrier
                           , MemBarrierOp_SSBB     // Speculative Synchronization Barrier to VA
                           , MemBarrierOp_PSSBB     // Speculative Synchronization Barrier to PA
                           , MemBarrierOp_SB       // Speculation Barrier
                           };
```

## Library pseudocode for aarch64/instrs/system/hints/syshintop/SystemHintOp

```
enumeration SystemHintOp {
    SystemHintOp_NOP,
    SystemHintOp_YIELD,
    SystemHintOp_WFE,
    SystemHintOp_WFI,
    SystemHintOp_SEV,
    SystemHintOp_SEVL,
    SystemHintOp_DGH,
    SystemHintOp_ESB,
    SystemHintOp_PSB,
    SystemHintOp_TSB,
    SystemHintOp_BTI,
    SystemHintOp_WFET,
    SystemHintOp_WFIT,
    SystemHintOp_CSDB
};
```

## Library pseudocode for aarch64/instrs/system/register/cpsr/pstatefield/PSTATEField

```
enumeration PSTATEField {PSTATEField_DAIFSet, PSTATEField_DAIFClr,
                        PSTATEField_PAN, // Armv8.1
                        PSTATEField_UA0, // Armv8.2
                        PSTATEField_DIT, // Armv8.4
                        PSTATEField_SSBS,
                        PSTATEField_TC0, // Armv8.5
                        PSTATEField_SP
                        };
```

## Library pseudocode for aarch64/instrs/system/sysops/sysop/SysOp

```
// SysOp()
// =====

SystemOp SysOp(bits(3) op1, bits(4) CRn, bits(4) CRm, bits(3) op2)
  case op1:CRn:CRm:op2 of
    when '000 0111 1000 000' return Sys_AT;    // S1E1R
    when '100 0111 1000 000' return Sys_AT;    // S1E2R
    when '110 0111 1000 000' return Sys_AT;    // S1E3R
    when '000 0111 1000 001' return Sys_AT;    // S1E1W
    when '100 0111 1000 001' return Sys_AT;    // S1E2W
    when '110 0111 1000 001' return Sys_AT;    // S1E3W
    when '000 0111 1000 010' return Sys_AT;    // S1E0R
    when '000 0111 1000 011' return Sys_AT;    // S1E0W
    when '100 0111 1000 100' return Sys_AT;    // S12E1R
    when '100 0111 1000 101' return Sys_AT;    // S12E1W
    when '100 0111 1000 110' return Sys_AT;    // S12E0R
    when '100 0111 1000 111' return Sys_AT;    // S12E0W
    when '011 0111 0100 001' return Sys_DC;    // ZVA
    when '000 0111 0110 001' return Sys_DC;    // IVAC
    when '000 0111 0110 010' return Sys_DC;    // ISW
    when '011 0111 1010 001' return Sys_DC;    // CVAC
    when '000 0111 1010 010' return Sys_DC;    // CSW
    when '011 0111 1011 001' return Sys_DC;    // CVAU
    when '011 0111 1110 001' return Sys_DC;    // CIVAC
    when '000 0111 1110 010' return Sys_DC;    // CISW
    when '011 0111 1101 001' return Sys_DC;    // CVADP
    when '000 0111 0001 000' return Sys_IC;    // IALLUIS
    when '000 0111 0101 000' return Sys_IC;    // IALLU
    when '011 0111 0101 001' return Sys_IC;    // IVAU
    when '100 1000 0000 001' return Sys_TLBI;  // IPAS2E1IS
    when '100 1000 0000 101' return Sys_TLBI;  // IPAS2LE1IS
    when '000 1000 0011 000' return Sys_TLBI;  // VMALLE1IS
    when '100 1000 0011 000' return Sys_TLBI;  // ALLE2IS
    when '110 1000 0011 000' return Sys_TLBI;  // ALLE3IS
    when '000 1000 0011 001' return Sys_TLBI;  // VAE1IS
    when '100 1000 0011 001' return Sys_TLBI;  // VAE2IS
    when '110 1000 0011 001' return Sys_TLBI;  // VAE3IS
    when '000 1000 0011 010' return Sys_TLBI;  // ASIDE1IS
    when '000 1000 0011 011' return Sys_TLBI;  // VAAE1IS
    when '100 1000 0011 100' return Sys_TLBI;  // ALLE1IS
    when '000 1000 0011 101' return Sys_TLBI;  // VALE1IS
    when '100 1000 0011 101' return Sys_TLBI;  // VALE2IS
    when '110 1000 0011 101' return Sys_TLBI;  // VALE3IS
    when '100 1000 0011 110' return Sys_TLBI;  // VMALLS12E1IS
    when '000 1000 0011 111' return Sys_TLBI;  // VAALE1IS
    when '100 1000 0100 001' return Sys_TLBI;  // IPAS2E1
    when '100 1000 0100 101' return Sys_TLBI;  // IPAS2LE1
    when '000 1000 0111 000' return Sys_TLBI;  // VMALLE1
    when '100 1000 0111 000' return Sys_TLBI;  // ALLE2
    when '110 1000 0111 000' return Sys_TLBI;  // ALLE3
    when '000 1000 0111 001' return Sys_TLBI;  // VAE1
    when '100 1000 0111 001' return Sys_TLBI;  // VAE2
    when '110 1000 0111 001' return Sys_TLBI;  // VAE3
    when '000 1000 0111 010' return Sys_TLBI;  // ASIDE1
    when '000 1000 0111 011' return Sys_TLBI;  // VAAE1
    when '100 1000 0111 100' return Sys_TLBI;  // ALLE1
    when '000 1000 0111 101' return Sys_TLBI;  // VALE1
    when '100 1000 0111 101' return Sys_TLBI;  // VALE2
    when '110 1000 0111 101' return Sys_TLBI;  // VALE3
    when '100 1000 0111 110' return Sys_TLBI;  // VMALLS12E1
    when '000 1000 0111 111' return Sys_TLBI;  // VAALE1
  return Sys_SYS;
```

## Library pseudocode for aarch64/instrs/system/sysops/sysop/SystemOp

```
enumeration SystemOp {Sys_AT, Sys_DC, Sys_IC, Sys_TLBI, Sys_SYS};
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/AArch32.DTLBI\_ALL

```
// AArch32.DTLBI_ALL()
// =====
// Invalidate all data TLB entries for the indicated translation regime with the
// the indicated security state for all TLBs within the indicated shareability domain.
// Invalidation applies to all applicable stage 1 and stage 2 entries.
// The indicated attr defines the attributes of the memory operations that must be completed in
// order to deem this operation to be completed.

AArch32.DTLBI_ALL(SecurityState security, Regime regime, Shareability shareability, TLBIMemAttr attr)
    assert PSTATE.EL IN {EL3, EL2, EL1};

    TLBIRecord r;
    r.op          = TLBIOp_DALL;
    r.from_aarch64 = FALSE;
    r.security     = security;
    r.regime       = regime;
    r.level        = TLBILevel\_Any;
    r.attr         = attr;

    TLBI(r);
    if shareability != Shareability\_NSH then Broadcast(shareability, r);
    return;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/AArch32.DTLBI\_ASID

```
// AArch32.DTLBI_ASID()
// =====
// Invalidate all data TLB stage 1 entries matching the indicated VMID (where regime supports)
// and ASID in the parameter Rt in the indicated translation regime with the
// indicated security state for all TLBs within the indicated shareability domain.
// Note: stage 1 and stage 2 combined entries are in the scope of this operation.
// The indicated attr defines the attributes of the memory operations that must be completed in
// order to deem this operation to be completed.
// When attr is TLBI_ExcludeXS, only operations with XS=0 within the scope of this TLB operation
// are required to complete.

AArch32.DTLBI_ASID(SecurityState security, Regime regime, bits(16) vmid, Shareability shareability,
    TLBIMemAttr attr, bits(32) Rt)
    assert PSTATE.EL IN {EL3, EL2, EL1};

    TLBIRecord r;
    r.op          = TLBIOp_DASID;
    r.from_aarch64 = FALSE;
    r.security     = security;
    r.regime       = regime;
    r.vmid         = vmid;
    r.level        = TLBILevel\_Any;
    r.attr         = attr;
    r.asid         = Zeros(8) : Rt<7:0>;

    TLBI(r);
    if shareability != Shareability\_NSH then Broadcast(shareability, r);
    return;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/AArch32.DTLBI\_VA

```
// AArch32.DTLBI_VA()
// =====
// Invalidate by VA all stage 1 data TLB entries in the indicated shareability domain
// matching the indicated VMID and ASID (where regime supports VMID, ASID) in the indicated regime
// with the indicated security state.
// ASID, VA and related parameters are derived from Rt.
// Note: stage 1 and stage 2 combined entries are in the scope of this operation.
// When the indicated level is
//     TLBILevel_Any : this applies to TLB entries at all levels
//     TLBILevel_Last : this applies to TLB entries at last level only
// The indicated attr defines the attributes of the memory operations that must be completed in
// order to deem this operation to be completed.
// When attr is TLBI_ExcludeXS, only operations with XS=0 within the scope of this TLB operation
// are required to complete.

AArch32.DTLBI_VA(SecurityState security, Regime regime, bits(16) vmid,
                 Shareability shareability, TLBILevel level, TLBIMemAttr attr, bits(32) Rt)
    assert PSTATE.EL IN {EL3, EL2, EL1};

    TLBIRecord r;
    r.op          = TLBIOp_DVA;
    r.from_aarch64 = FALSE;
    r.security     = security;
    r.regime       = regime;
    r.vmid         = vmid;
    r.level        = level;
    r.attr         = attr;
    r.asid         = Zeros(8) : Rt<7:0>;

    r.address.address = Zeros(20) : Rt<31:12> : Zeros(12);

    TLBI(r);
    if shareability != Shareability\_NSH then Broadcast(shareability, r);
    return;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/AArch32.ITLBI\_ALL

```
// AArch32.ITLBI_ALL()
// =====
// Invalidate all instruction TLB entries for the indicated translation regime with the
// the indicated security state for all TLBs within the indicated shareability domain.
// Invalidation applies to all applicable stage 1 and stage 2 entries.
// The indicated attr defines the attributes of the memory operations that must be completed in
// order to deem this operation to be completed.

AArch32.ITLBI_ALL(SecurityState security, Regime regime, Shareability shareability, TLBIMemAttr attr)
    assert PSTATE.EL IN {EL3, EL2, EL1};

    TLBIRecord r;
    r.op          = TLBIOp_IALL;
    r.from_aarch64 = FALSE;
    r.security     = security;
    r.regime       = regime;
    r.level        = TLBILevel\_Any;
    r.attr         = attr;

    TLBI(r);
    if shareability != Shareability\_NSH then Broadcast(shareability, r);
    return;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/AArch32.ITLBI\_ASID

```
// AArch32.ITLBI_ASID()
// =====
// Invalidate all instruction TLB stage 1 entries matching the indicated VMID (where regime supports)
// and ASID in the parameter Rt in the indicated translation regime with the
// indicated security state for all TLBs within the indicated shareability domain.
// Note: stage 1 and stage 2 combined entries are in the scope of this operation.
// The indicated attr defines the attributes of the memory operations that must be completed in
// order to deem this operation to be completed.
// When attr is TLBI_ExcludeXS, only operations with XS=0 within the scope of this TLB operation
// are required to complete.

AArch32.ITLBI_ASID(SecurityState security, Regime regime, bits(16) vmid, Shareability shareability,
TLBIMemAttr attr, bits(32) Rt)
    assert PSTATE.EL IN {EL3, EL2, EL1};

    TLBIRecord r;
    r.op          = TLBIOp_IASID;
    r.from_aarch64 = FALSE;
    r.security     = security;
    r.regime       = regime;
    r.vmid         = vmid;
    r.level        = TLBILevel\_Any;
    r.attr         = attr;
    r.asid         = Zeros(8) : Rt<7:0>;

    TLBI(r);
    if shareability != Shareability\_NSH then Broadcast(shareability, r);
    return;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/AArch32.ITLBI\_VA

```
// AArch32.ITLBI_VA()
// =====
// Invalidate by VA all stage 1 instruction TLB entries in the indicated shareability domain
// matching the indicated VMID and ASID (where regime supports VMID, ASID) in the indicated regime
// with the indicated security state.
// ASID, VA and related parameters are derived from Rt.
// Note: stage 1 and stage 2 combined entries are in the scope of this operation.
// When the indicated level is
//     TLBILevel_Any : this applies to TLB entries at all levels
//     TLBILevel_Last : this applies to TLB entries at last level only
// The indicated attr defines the attributes of the memory operations that must be completed in
// order to deem this operation to be completed.
// When attr is TLBI_ExcludeXS, only operations with XS=0 within the scope of this TLB operation
// are required to complete.

AArch32.ITLBI_VA(SecurityState security, Regime regime, bits(16) vmid,
Shareability shareability, TLBILevel level, TLBIMemAttr attr, bits(32) Rt)
    assert PSTATE.EL IN {EL3, EL2, EL1};

    TLBIRecord r;
    r.op          = TLBIOp_IVA;
    r.from_aarch64 = FALSE;
    r.security     = security;
    r.regime       = regime;
    r.vmid         = vmid;
    r.level        = level;
    r.attr         = attr;
    r.asid         = Zeros(8) : Rt<7:0>;

    r.address.address = Zeros(20) : Rt<31:12> : Zeros(12);

    TLBI(r);
    if shareability != Shareability\_NSH then Broadcast(shareability, r);
    return;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/AArch32.TLBI\_ALL

```
// AArch32.TLBI_ALL()
// =====
// Invalidate all entries for the indicated translation regime with the
// the indicated security state for all TLBs within the indicated shareability domain.
// Invalidation applies to all applicable stage 1 and stage 2 entries.
// The indicated attr defines the attributes of the memory operations that must be completed in
// order to deem this operation to be completed.
// When attr is TLBI_ExcludeXS, only operations with XS=0 within the scope of this TLB operation
// are required to complete.

AArch32.TLBI_ALL(SecurityState security, Regime regime, Shareability shareability, TLBIMemAttr attr)
    assert PSTATE.EL IN {EL3, EL2};

    TLBIRecord r;
    r.op          = TLBIOp_ALL;
    r.from_aarch64 = FALSE;
    r.security     = security;
    r.regime       = regime;
    r.level        = TLBIlevel\_Any;
    r.attr         = attr;

    TLBI(r);
    if shareability != Shareability\_NSH then Broadcast(shareability, r);
    return;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/AArch32.TLBI\_ASID

```
// AArch32.TLBI_ASID()
// =====
// Invalidate all stage 1 entries matching the indicated VMID (where regime supports)
// and ASID in the parameter Rt in the indicated translation regime with the
// indicated security state for all TLBs within the indicated shareability domain.
// Note: stage 1 and stage 2 combined entries are in the scope of this operation.
// The indicated attr defines the attributes of the memory operations that must be completed in
// order to deem this operation to be completed.
// When attr is TLBI_ExcludeXS, only operations with XS=0 within the scope of this TLB operation
// are required to complete.

AArch32.TLBI_ASID(SecurityState security, Regime regime, bits(16) vmid, Shareability shareability,
    TLBIMemAttr attr, bits(32) Rt)
    assert PSTATE.EL IN {EL3, EL2, EL1};

    TLBIRecord r;
    r.op          = TLBIOp_ASID;
    r.from_aarch64 = FALSE;
    r.security     = security;
    r.regime       = regime;
    r.vmid         = vmid;
    r.level        = TLBIlevel\_Any;
    r.attr         = attr;
    r.asid         = Zeros(8) : Rt<7:0>;

    TLBI(r);
    if shareability != Shareability\_NSH then Broadcast(shareability, r);
    return;
```



## Library pseudocode for aarch64/instrs/system/sysops/tlbi/AArch32.TLBI\_IPAS2

```
// AArch32.TLBI_IPAS2()
// =====
// Invalidate by IPA all stage 2 only TLB entries in the indicated shareability
// domain matching the indicated VMID in the indicated regime with the indicated security state.
// Note: stage 1 and stage 2 combined entries are not in the scope of this operation.
// IPA and related parameters of the are derived from Rt.
// When the indicated level is
//     TLBILevel_Any : this applies to TLB entries at all levels
//     TLBILevel_Last : this applies to TLB entries at last level only
// The indicated attr defines the attributes of the memory operations that must be completed in
// order to deem this operation to be completed.
// When attr is TLBI_ExcludeXS, only operations with XS=0 within the scope of this TLB operation
// are required to complete.

AArch32.TLBI_IPAS2(SecurityState security, Regime regime, bits(16) vmid,
                  Shareability shareability, TLBILevel level, TLBIMemAttr attr, bits(32) Rt)
assert PSTATE.EL IN {EL3, EL2};
assert security == SS\_NonSecure;

TLBIRecord r;
r.op          = TLBIOp_IPAS2;
r.from_aarch64 = FALSE;
r.security     = security;
r.regime       = regime;
r.vmid         = vmid;
r.level        = level;
r.attr         = attr;

r.address.address = Zeros(12) : Rt<27:0> : Zeros(12);
r.address.paspace = PAS_NonSecure;

TLBI(r);
if shareability != Shareability\_NSH then Broadcast(shareability, r);
return;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/AArch32.TLBI\_VA

```
// AArch32.TLBI_VA()
// =====
// Invalidate by VA all stage 1 TLB entries in the indicated shareability domain
// matching the indicated VMID and ASID (where regime supports VMID, ASID) in the indicated regime
// with the indicated security state.
// ASID, VA and related parameters are derived from Rt.
// Note: stage 1 and stage 2 combined entries are in the scope of this operation.
// When the indicated level is
//     TLBILevel_Any : this applies to TLB entries at all levels
//     TLBILevel_Last : this applies to TLB entries at last level only
// The indicated attr defines the attributes of the memory operations that must be completed in
// order to deem this operation to be completed.
// When attr is TLBI_ExcludeXS, only operations with XS=0 within the scope of this TLB operation
// are required to complete.

AArch32.TLBI_VA(SecurityState security, Regime regime, bits(16) vmid,
                Shareability shareability, TLBILevel level, TLBIMemAttr attr, bits(32) Rt)
    assert PSTATE.EL IN {EL3, EL2, EL1};

    TLBIRecord r;
    r.op          = TLBIOp_VA;
    r.from_aarch64 = FALSE;
    r.security     = security;
    r.regime       = regime;
    r.vmid         = vmid;
    r.level        = level;
    r.attr         = attr;
    r.asid         = Zeros(8) : Rt<7:0>;

    r.address.address = Zeros(20) : Rt<31:12> : Zeros(12);

    TLBI(r);
    if shareability != Shareability\_NSH then Broadcast(shareability, r);
    return;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/AArch32.TLBI\_VAA

```
// AArch32.TLBI_VAA()
// =====
// Invalidate by VA all stage 1 TLB entries in the indicated shareability domain
// matching the indicated VMID (where regime supports VMID) and all ASID in the indicated regime
// with the indicated security state.
// VA and related parameters are derived from Rt.
// Note: stage 1 and stage 2 combined entries are in the scope of this operation.
// When the indicated level is
//     TLBILevel_Any : this applies to TLB entries at all levels
//     TLBILevel_Last : this applies to TLB entries at last level only
// The indicated attr defines the attributes of the memory operations that must be completed in
// order to deem this operation to be completed.
// When attr is TLBI_ExcludeXS, only operations with XS=0 within the scope of this TLB operation
// are required to complete.

AArch32.TLBI_VAA(SecurityState security, Regime regime, bits(16) vmid,
                 Shareability shareability, TLBILevel level, TLBIMemAttr attr, bits(32) Rt)
    assert PSTATE.EL IN {EL3, EL2, EL1};

    TLBIRecord r;
    r.op          = TLBIOp_VAA;
    r.from_aarch64 = TRUE;
    r.security     = security;
    r.regime       = regime;
    r.vmid         = vmid;
    r.level        = level;
    r.attr         = attr;

    r.address.address = Zeros(20) : Rt<31:12> : Zeros(12);

    TLBI(r);
    if shareability != Shareability\_NSH then Broadcast(shareability, r);
    return;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/AArch32.TLBI\_VMALL

```
// AArch32.TLBI_VMALL()
// =====
// Invalidate all stage 1 entries for the indicated translation regime with the
// the indicated security state for all TLBs within the indicated shareability
// domain that match the indicated VMID (where applicable).
// Note: stage 1 and stage 2 combined entries are in the scope of this operation.
// Note: stage 2 only entries are not in the scope of this operation.
// The indicated attr defines the attributes of the memory operations that must be completed in
// order to deem this operation to be completed.
// When attr is TLBI_ExcludeXS, only operations with XS=0 within the scope of this TLB operation
// are required to complete.

AArch32.TLBI_VMALL(SecurityState security, Regime regime, bits(16) vmid,
                  Shareability shareability, TLBIMemAttr attr)
    assert PSTATE.EL IN {EL3, EL2, EL1};

    TLBIRecord r;
    r.op          = TLBIOp_VMALL;
    r.from_aarch64 = FALSE;
    r.security     = security;
    r.regime       = regime;
    r.level        = TLBILevel\_Any;
    r.vmid         = vmid;
    r.attr         = attr;

    TLBI(r);
    if shareability != Shareability\_NSH then Broadcast(shareability, r);
    return;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/AArch32.TLBI\_VMALLS12

```
// AArch32.TLBI_VMALLS12()
// =====
// Invalidate all stage 1 and stage 2 entries for the indicated translation
// regime with the indicated security state for all TLBs within the indicated
// shareability domain that match the indicated VMID.
// The indicated attr defines the attributes of the memory operations that must be completed in
// order to deem this operation to be completed.
// When attr is TLBI_ExcludeXS, only operations with XS=0 within the scope of this TLB operation
// are required to complete.

AArch32.TLBI_VMALLS12(SecurityState security, Regime regime, bits(16) vmid,
                     Shareability shareability, TLBIMemAttr attr)
    assert PSTATE.EL IN {EL3, EL2};

    TLBIRecord r;
    r.op          = TLBIOp_VMALLS12;
    r.from_aarch64 = FALSE;
    r.security     = security;
    r.regime       = regime;
    r.level        = TLBILevel\_Any;
    r.vmid         = vmid;
    r.attr         = attr;

    TLBI(r);
    if shareability != Shareability\_NSH then Broadcast(shareability, r);
    return;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/AArch64.TLBI\_ALL

```
// AArch64.TLBI_ALL()
// =====
// Invalidate all entries for the indicated translation regime with the
// the indicated security state for all TLBs within the indicated shareability domain.
// Invalidation applies to all applicable stage 1 and stage 2 entries.
// The indicated attr defines the attributes of the memory operations that must be completed in
// order to deem this operation to be completed.
// When attr is TLBI_ExcludeXS, only operations with XS=0 within the scope of this TLB operation
// are required to complete.

AArch64.TLBI_ALL(SecurityState security, Regime regime, Shareability shareability, TLBIMemAttr attr)
    assert PSTATE.EL IN {EL3, EL2};

    TLBIRecord r;
    r.op          = TLBIOp_ALL;
    r.from_aarch64 = TRUE;
    r.security     = security;
    r.regime       = regime;
    r.level        = TLBILevel\_Any;
    r.attr         = attr;

    TLBI(r);
    if shareability != Shareability\_NSH then Broadcast(shareability, r);
    return;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/AArch64.TLBI\_ASID

```
// AArch64.TLBI_ASID()
// =====
// Invalidate all stage 1 entries matching the indicated VMID (where regime supports)
// and ASID in the parameter Xt in the indicated translation regime with the
// indicated security state for all TLBs within the indicated shareability domain.
// Note: stage 1 and stage 2 combined entries are in the scope of this operation.
// The indicated attr defines the attributes of the memory operations that must be completed in
// order to deem this operation to be completed.
// When attr is TLBI_ExcludeXS, only operations with XS=0 within the scope of this TLB operation
// are required to complete.

AArch64.TLBI_ASID(SecurityState security, Regime regime, bits(16) vmid, Shareability shareability,
TLBIMemAttr attr, bits(64) Xt)
    assert PSTATE.EL IN {EL3, EL2, EL1};

    TLBIRecord r;
    r.op          = TLBIOp_ASID;
    r.from_aarch64 = TRUE;
    r.security     = security;
    r.regime       = regime;
    r.vmid         = vmid;
    r.level        = TLBILevel\_Any;
    r.attr         = attr;
    r.asid         = Xt<63:48>;

    TLBI(r);
    if shareability != Shareability\_NSH then Broadcast(shareability, r);
    return;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/AArch64.TLBI\_IPAS2

```
// AArch64.TLBI_IPAS2()
// =====
// Invalidate by IPA all stage 2 only TLB entries in the indicated shareability
// domain matching the indicated VMID in the indicated regime with the indicated security state.
// Note: stage 1 and stage 2 combined entries are not in the scope of this operation.
// IPA and related parameters of the are derived from Xt.
// When the indicated level is
//     TLBILevel_Any : this applies to TLB entries at all levels
//     TLBILevel_Last : this applies to TLB entries at last level only
// The indicated attr defines the attributes of the memory operations that must be completed in
// order to deem this operation to be completed.
// When attr is TLBI_ExcludeXS, only operations with XS=0 within the scope of this TLB operation
// are required to complete.

AArch64.TLBI_IPAS2(SecurityState security, Regime regime, bits(16) vmid,
                  Shareability shareability, TLBILevel level, TLBIMemAttr attr, bits(64) Xt)
    assert PSTATE.EL IN {EL3, EL2};

    TLBIRecord r;
    r.op          = TLBIOp_IPAS2;
    r.from_aarch64 = TRUE;
    r.security     = security;
    r.regime       = regime;
    r.vmid        = vmid;
    r.level       = level;
    r.attr        = attr;
    r.ttl         = Xt<47:44>;

    r.address.address = Xt<39:0> : Zeros(12);

    case security of
        when SS\_NonSecure
            r.address.paspace = PAS_NonSecure;
        when SS\_Secure
            r.address.paspace = if Xt<63> == '1' then PAS_NonSecure else PAS_Secure;

    TLBI(r);
    if shareability != Shareability\_NSH then Broadcast(shareability, r);
    return;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/AArch64.TLBI\_RIPAS2

```
// AArch64.TLBI_RIPAS2()
// =====
// Range invalidate by IPA all stage 2 only TLB entries in the indicated
// shareability domain matching the indicated VMID in the indicated regime with the indicated
// security state.
// Note: stage 1 and stage 2 combined entries are not in the scope of this operation.
// The range of IPA and related parameters of the are derived from Xt.
// When the indicated level is
//     TLBILevel_Any : this applies to TLB entries at all levels
//     TLBILevel_Last : this applies to TLB entries at last level only
// The indicated attr defines the attributes of the memory operations that must be completed in
// order to deem this operation to be completed.
// When attr is TLBI_ExcludeXS, only operations with XS=0 within the scope of this TLB operation
// are required to complete.

AArch64.TLBI_RIPAS2(SecurityState security, Regime regime, bits(16) vmid,
                    Shareability shareability, TLBILevel level, TLBIMemAttr attr, bits(64) Xt)
    assert PSTATE.EL IN {EL3, EL2, EL1};

    TLBIRecord r;
    r.op          = TLBIOp_RIPAS2;
    r.from_aarch64 = TRUE;
    r.security     = security;
    r.regime       = regime;
    r.vmid         = vmid;
    r.level        = level;
    r.attr         = attr;
    r.ttl          = Xt<47:44>;

    bits(2) tg      = Xt<47:46>;
    integer scale    = UInt(Xt<45:44>);
    integer num      = UInt(Xt<43:39>);
    integer baseaddr = SInt(Xt<36:0>);

    bits(64) start_address;
    boolean valid;

    (valid, r.tg, start_address, r.end_address) = TLBIRange(regime, Xt);

    if !valid then return;

    r.address.address = start_address<51:0>;

    case security of
        when SS\_NonSecure
            r.address.paspace = PAS_NonSecure;
        when SS\_Secure
            r.address.paspace = if Xt<63> == '1' then PAS_NonSecure else PAS_Secure;

    TLBI(r);
    if shareability != Shareability\_NSH then Broadcast(shareability, r);
    return;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/AArch64.TLBI\_RVA

```
// AArch64.TLBI_RVA()
// =====
// Range invalidate by VA range all stage 1 TLB entries in the indicated
// shareability domain matching the indicated VMID and ASID (where regime
// supports VMID, ASID) in the indicated regime with the indicated security state.
// ASID, and range related parameters are derived from Xt.
// Note: stage 1 and stage 2 combined entries are in the scope of this operation.
// When the indicated level is
//     TLBILevel_Any : this applies to TLB entries at all levels
//     TLBILevel_Last : this applies to TLB entries at last level only
// The indicated attr defines the attributes of the memory operations that must be completed in
// order to deem this operation to be completed.
// When attr is TLBI_ExcludeXS, only operations with XS=0 within the scope of this TLB operation
// are required to complete.

AArch64.TLBI_RVA(SecurityState security, Regime regime, bits(16) vmid,
                 Shareability shareability, TLBILevel level, TLBIMemAttr attr, bits(64) Xt)
    assert PSTATE.EL IN {EL3, EL2, EL1};

    TLBIRecord r;
    r.op          = TLBIOp_RVA;
    r.from_aarch64 = TRUE;
    r.security     = security;
    r.regime       = regime;
    r.vmid         = vmid;
    r.level        = level;
    r.attr         = attr;
    r.asid         = Xt<63:48>;
    r.ttl          = Xt<47:44>;

    bits(64) start_address;
    boolean valid;

    (valid, r.tg, start_address, r.end_address) = TLBIRange(regime, Xt);

    if !valid then return;

    r.address.address = start_address<51:0>;
    if security == SS\_Secure && Xt<63> == '0' then
        r.address.paspace = PAS_Secure;
    else
        r.address.paspace = PAS_NonSecure;

    TLBI(r);
    if shareability != Shareability\_NSH then Broadcast(shareability, r);
    return;
```



## Library pseudocode for aarch64/instrs/system/sysops/tlbi/AArch64.TLBI\_RVAA

```
// AArch64.TLBI_RVAA()
// =====
// Range invalidate by VA range all stage 1 TLB entries in the indicated
// shareability domain matching the indicated VMID (where regimesupports VMID)
// and all ASID in the indicated regime with the indicated security state.
// VA range related parameters are derived from Xt.
// Note: stage 1 and stage 2 combined entries are in the scope of this operation.
// When the indicated level is
//     TLBILevel_Any : this applies to TLB entries at all levels
//     TLBILevel_Last : this applies to TLB entries at last level only
// The indicated attr defines the attributes of the memory operations that must be completed in
// order to deem this operation to be completed.
// When attr is TLBI_ExcludeXS, only operations with XS=0 within the scope of this TLB operation
// are required to complete.

AArch64.TLBI_RVAA(SecurityState security, Regime regime, bits(16) vmid,
                  Shareability shareability, TLBILevel level, TLBIMemAttr attr, bits(64) Xt)
    assert PSTATE.EL IN {EL3, EL2, EL1};

    TLBIRecord r;
    r.op          = TLBIOp_RVAA;
    r.from_aarch64 = TRUE;
    r.security     = security;
    r.regime       = regime;
    r.vmid         = vmid;
    r.level        = level;
    r.attr         = attr;
    r.ttl          = Xt<47:44>;

    bits(2) tg      = Xt<47:46>;
    integer scale    = UInt(Xt<45:44>);
    integer num      = UInt(Xt<43:39>);
    integer baseaddr = SInt(Xt<36:0>);

    bits(64) start_address;
    boolean valid;

    (valid, r.tg, start_address, r.end_address) = TLBIRange(regime, Xt);

    if !valid then return;

    r.address.address = start_address<51:0>;

    TLBI(r);
    if shareability != Shareability\_NSH then Broadcast(shareability, r);
    return;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/AArch64.TLBI\_VA

```
// AArch64.TLBI_VA()
// =====
// Invalidate by VA all stage 1 TLB entries in the indicated shareability domain
// matching the indicated VMID and ASID (where regime supports VMID, ASID) in the indicated regime
// with the indicated security state.
// ASID, VA and related parameters are derived from Xt.
// Note: stage 1 and stage 2 combined entries are in the scope of this operation.
// When the indicated level is
//     TLBILevel_Any : this applies to TLB entries at all levels
//     TLBILevel_Last : this applies to TLB entries at last level only
// The indicated attr defines the attributes of the memory operations that must be completed in
// order to deem this operation to be completed.
// When attr is TLBI_ExcludeXS, only operations with XS=0 within the scope of this TLB operation
// are required to complete.

AArch64.TLBI_VA(SecurityState security, Regime regime, bits(16) vmid,
               Shareability shareability, TLBILevel level, TLBIMemAttr attr, bits(64) Xt)
    assert PSTATE.EL IN {EL3, EL2, EL1};

    TLBIRecord r;
    r.op          = TLBIOp_VA;
    r.from_aarch64 = TRUE;
    r.security     = security;
    r.regime       = regime;
    r.vmid         = vmid;
    r.level        = level;
    r.attr         = attr;
    r.asid         = Xt<63:48>;
    r.ttl          = Xt<47:44>;

    r.address.address = Xt<39:0> : Zeros(12);

    TLBI(r);
    if shareability != Shareability\_NSH then Broadcast(shareability, r);
    return;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/AArch64.TLBI\_VAA

```
// AArch64.TLBI_VAA()
// =====
// Invalidate by VA all stage 1 TLB entries in the indicated shareability domain
// matching the indicated VMID (where regime supports VMID) and all ASID in the indicated regime
// with the indicated security state.
// VA and related parameters are derived from Xt.
// Note: stage 1 and stage 2 combined entries are in the scope of this operation.
// When the indicated level is
//     TLBILevel_Any : this applies to TLB entries at all levels
//     TLBILevel_Last : this applies to TLB entries at last level only
// The indicated attr defines the attributes of the memory operations that must be completed in
// order to deem this operation to be completed.
// When attr is TLBI_ExcludeXS, only operations with XS=0 within the scope of this TLB operation
// are required to complete.

AArch64.TLBI_VAA(SecurityState security, Regime regime, bits(16) vmid,
                 Shareability shareability, TLBILevel level, TLBIMemAttr attr, bits(64) Xt)
    assert PSTATE.EL IN {EL3, EL2, EL1};

    TLBIRecord r;
    r.op          = TLBIOp_VAA;
    r.from_aarch64 = TRUE;
    r.security     = security;
    r.regime       = regime;
    r.vmid         = vmid;
    r.level        = level;
    r.attr         = attr;
    r.ttl          = Xt<47:44>;

    r.address.address = Xt<39:0> : Zeros(12);

    TLBI(r);
    if shareability != Shareability\_NSH then Broadcast(shareability, r);
    return;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/AArch64.TLBI\_VMALL

```
// AArch64.TLBI_VMALL()
// =====
// Invalidate all stage 1 entries for the indicated translation regime with the
// the indicated security state for all TLBs within the indicated shareability
// domain that match the indicated VMID (where applicable).
// Note: stage 1 and stage 2 combined entries are in the scope of this operation.
// Note: stage 2 only entries are not in the scope of this operation.
// The indicated attr defines the attributes of the memory operations that must be completed in
// order to deem this operation to be completed.
// When attr is TLBI_ExcludeXS, only operations with XS=0 within the scope of this TLB operation
// are required to complete.

AArch64.TLBI_VMALL(SecurityState security, Regime regime, bits(16) vmid,
                  Shareability shareability, TLBIMemAttr attr)
    assert PSTATE.EL IN {EL3, EL2, EL1};

    TLBIRecord r;
    r.op          = TLBIOp_VMALL;
    r.from_aarch64 = TRUE;
    r.security     = security;
    r.regime       = regime;
    r.level        = TLBILevel\_Any;
    r.vmid         = vmid;
    r.attr         = attr;

    TLBI(r);
    if shareability != Shareability\_NSH then Broadcast(shareability, r);
    return;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/AArch64.TLBI\_VMALLS12

```
// AArch64.TLBI_VMALLS12()
// =====
// Invalidate all stage 1 and stage 2 entries for the indicated translation
// regime with the indicated security state for all TLBs within the indicated
// shareability domain that match the indicated VMID.
// The indicated attr defines the attributes of the memory operations that must be completed in
// order to deem this operation to be completed.
// When attr is TLBI_ExcludeXS, only operations with XS=0 within the scope of this TLB operation
// are required to complete.

AArch64.TLBI_VMALLS12(SecurityState security, Regime regime, bits(16) vmid,
                     Shareability shareability, TLBIMemAttr attr)
    assert PSTATE.EL IN {EL3, EL2};

    TLBIRecord r;
    r.op          = TLBIOp_VMALLS12;
    r.from_aarch64 = TRUE;
    r.security     = security;
    r.regime       = regime;
    r.level        = TLBILevel\_Any;
    r.vmid         = vmid;
    r.attr         = attr;

    TLBI(r);
    if shareability != Shareability\_NSH then Broadcast(shareability, r);
    return;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/ASID\_NONE

```
constant bits(16) ASID_NONE = Zeros();
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/Broadcast

```
// Broadcast()
// =====
// IMPLEMENTATION DEFINED function to broadcast TLBI operation within the indicated shareability
// domain.

Broadcast(Shareability shareability, TLBIRecord r)
    IMPLEMENTATION_DEFINED;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/HasLargeAddress

```
// HasLargeAddress()
// =====
// Returns TRUE if the regime is configured for 52 bit addresses, FALSE otherwise.

boolean HasLargeAddress(Regime regime)
    if !Have52BitIPAAAndPASpaceExt() then
        return FALSE;
    case regime of
        when Regime\_EL3
            return TCR_EL3<32> == '1';
        when Regime\_EL2
            return TCR_EL2<32> == '1';
        when Regime\_EL20
            return TCR_EL2<59> == '1';
        when Regime\_EL10
            return TCR_EL1<59> == '1';
        otherwise
            Unreachable();
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/SecurityStateAtEL

```
// SecurityStateAtEL()
// =====
// Returns the effective security state at the exception level based off current settings.

SecurityState SecurityStateAtEL(bits(2) EL)
    if !HaveEL(EL3) then
        if boolean IMPLEMENTATION_DEFINED "Secure-only implementation" then
            return SS_Secure;
        else
            return SS_NonSecure;
    elsif EL == EL3 then
        return SS_Secure;
    else
        // For EL2 call only when EL2 is enabled in current security state
        assert(EL != EL2 || EL2Enabled());
        if !ELUsingAArch32(EL3) then
            return if SCR_EL3.NS == '1' then SS_NonSecure else SS_Secure;
        else
            return if SCR.NS == '1' then SS_NonSecure else SS_Secure;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/TLBI

```
// TLBI()
// =====
// Performs TLB maintenance of operation on TLB to invalidate the matching transition table entries.

TLBI(TLBIRRecord r)
    IMPLEMENTATION_DEFINED;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/TLBILevel

```
enumeration TLBILevel {
    TLBILevel_Any,
    TLBILevel_Last
};
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/TLBIMemAttr

```
enumeration TLBIMemAttr {
    TLBI_AllAttr,
    TLBI_ExcludeXS
};
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/TLBIOp

```
enumeration TLBIOp {
    TLBIOp_DALL,           // AArch32 Data TLBI operations - deprecated
    TLBIOp_DASID,
    TLBIOp_DVA,
    TLBIOp_IALL,           // AArch32 Instruction TLBI operations - deprecated
    TLBIOp_IASID,
    TLBIOp_IVA,
    TLBIOp_ALL,
    TLBIOp_ASID,
    TLBIOp_IPAS2,
    TLBIOp_VAA,
    TLBIOp_VA,
    TLBIOp_VMALL,
    TLBIOp_VMALLS12,
    TLBIOp_RIPAS2,
    TLBIOp_RVAA,
    TLBIOp_RVA,
};
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/TLBIRange

```
// TLBIRange()
// =====
// Extract the input address range information from encoded Xt.

(boolean, bits(2), bits(64), bits(64)) TLBIRange(Regime regime, bits(64) Xt)
    boolean valid = TRUE;
    bits(64) start = Zeros(64);
    bits(64) end   = Zeros(64);

    bits(2) tg      = Xt<47:46>;
    integer scale   = UInt(Xt<45:44>);
    integer num     = UInt(Xt<43:39>);
    integer tg_bits;

    if tg == '00' then
        return (FALSE, tg, start, end);

    case tg of
        when '01' // 4KB
            tg_bits = 12;
            if HasLargeAddress(regime) then
                start<52:16> = Xt<36:0>;
                start<63:53> = Replicate(Xt<36>, 11);
            else
                start<48:12> = Xt<36:0>;
                start<63:49> = Replicate(Xt<36>, 15);
        when '10' // 16KB
            tg_bits = 14;
            if HasLargeAddress(regime) then
                start<52:16> = Xt<36:0>;
                start<63:53> = Replicate(Xt<36>, 11);
            else
                start<50:14> = Xt<36:0>;
                start<63:51> = Replicate(Xt<36>, 13);
        when '11' // 64KB
            tg_bits = 16;
            start<52:16> = Xt<36:0>;
            start<63:53> = Replicate(Xt<36>, 11);
        otherwise
            Unreachable();

    integer range = (num+1) << (5*scale + 1 + tg_bits);
    end   = start + range<63:0>;

    if end<52> != start<52> then
        // overflow, saturate it
        end = Replicate(start<52>, 64-52) : Ones(52);

    return (valid, tg, start, end);
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/TLBIRecord

```
type TLBIRecord is (
    TLBIOp          op,
    boolean          from_aarch64, // originated as an AArch64 operation
    SecurityState   security,
    Regime           regime,
    bits(16)         vmid,
    bits(16)         asid,
    TLBILevel       level,
    TLBIMemAttr     attr,
    FullAddress      address,      // VA/IPA/BaseAddress
    bits(64)         end_address, // for range operations, end address
    bits(2)          tg,          // for range operations - translation granule
    bits(4)          ttl,         // transition table walk level holding the leaf entry for the address b
)
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/TLBI\_ALL

```
// TLBI_ALL()
// =====

TLBI_ALL(SecurityState security, Regime regime, Shareability shareability, TLBIMemAttr attr)
    if UsingAArch32() then
        AArch32.TLBI\_ALL(security, regime, shareability, attr);
    else
        AArch64.TLBI\_ALL(security, regime, shareability, attr);
    return;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/TLBI\_ASID

```
// TLBI_ASID()
// =====

TLBI_ASID(SecurityState security, Regime regime, bits(16) vmid, Shareability shareability,
    TLBIMemAttr attr, bits(N) reg)
    if UsingAArch32() then
        assert N == 32;
        AArch32.TLBI\_ASID(security, regime, vmid, shareability, attr, reg<31:0>);
    else
        assert N == 64;
        AArch64.TLBI\_ASID(security, regime, vmid, shareability, attr, reg<63:0>);
    return;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/TLBI\_IPAS2

```
// TLBI_IPAS2()
// =====

TLBI_IPAS2(SecurityState security, Regime regime, bits(16) vmid,
    Shareability shareability, TLBIlevel level, TLBIMemAttr attr, bits(N) reg)
    if UsingAArch32() then
        assert N == 32;
        AArch32.TLBI\_IPAS2(security, regime, vmid, shareability, level, attr, reg<31:0>);
    else
        assert N == 64;
        AArch64.TLBI\_IPAS2(security, regime, vmid, shareability, level, attr, reg<63:0>);
    return;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/TLBI\_RIPAS2

```
// TLBI_RIPAS2()
// =====

TLBI_RIPAS2(SecurityState security, Regime regime, bits(16) vmid,
    Shareability shareability, TLBIlevel level, TLBIMemAttr attr, bits(64) Xt)
    assert !UsingAArch32();

    AArch64.TLBI\_RIPAS2(security, regime, vmid, shareability, level, attr, Xt);
    return;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/TLBI\_RVA

```
// TLBI_RVA()
// =====

TLBI_RVA(SecurityState security, Regime regime, bits(16) vmid,
    Shareability shareability, TLBIlevel level, TLBIMemAttr attr, bits(64) Xt)
    assert !UsingAArch32();

    AArch64.TLBI\_RVA(security, regime, vmid, shareability, level, attr, Xt);
    return;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/TLBI\_RVAA

```
// TLBI_RVAA()
// =====

TLBI_RVAA(SecurityState security, Regime regime, bits(16) vmid,
         Shareability shareability, TLBILevel level, TLBIMemAttr attr, bits(64) Xt)
    assert !UsingAArch32();

    AArch64.TLBI\_RVAA(security, regime, vmid, shareability, level, attr, Xt);
    return;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/TLBI\_VA

```
// TLBI_VA()
// =====

TLBI_VA(SecurityState security, Regime regime, bits(16) vmid,
       Shareability shareability, TLBILevel level, TLBIMemAttr attr, bits(N) reg)
    if UsingAArch32() then
        assert N == 32;
        AArch32.TLBI\_VA(security, regime, vmid, shareability, level, attr, reg<31:0>);
    else
        assert N == 64;
        AArch64.TLBI\_VA(security, regime, vmid, shareability, level, attr, reg<63:0>);
    return;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/TLBI\_VAA

```
// TLBI_VAA()
// =====

TLBI_VAA(SecurityState security, Regime regime, bits(16) vmid,
        Shareability shareability, TLBILevel level, TLBIMemAttr attr, bits(N) reg)
    if UsingAArch32() then
        assert N == 32;
        AArch32.TLBI\_VAA(security, regime, vmid, shareability, level, attr, reg<31:0>);
    else
        assert N == 64;
        AArch64.TLBI\_VAA(security, regime, vmid, shareability, level, attr, reg<63:0>);
    return;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/TLBI\_VMALL

```
// TLBI_VMALL()
// =====

TLBI_VMALL(SecurityState security, Regime regime, bits(16) vmid,
          Shareability shareability, TLBIMemAttr attr)
    if UsingAArch32() then
        AArch32.TLBI\_VMALL(security, regime, vmid, shareability, attr);
    else
        AArch64.TLBI\_VMALL(security, regime, vmid, shareability, attr);
    return;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/TLBI\_VMALLS12

```
// TLBI_VMALLS12()
// =====

TLBI_VMALLS12(SecurityState security, Regime regime, bits(16) vmid,
             Shareability shareability, TLBIMemAttr attr)
    if UsingAArch32() then
        AArch32.TLBI\_VMALLS12(security, regime, vmid, shareability, attr);
    else
        AArch64.TLBI\_VMALLS12(security, regime, vmid, shareability, attr);
    return;
```



## Library pseudocode for aarch64/instrs/system/sysops/tlbi/VMID

```
// VMID[]
// =====
// Effective VMID.

bits(16) VMID[]
    if EL2Enabled\(\) then
        if !ELUsingAArch32\(EL2\) then
            if Have16bitVMID\(\) && VTCR_EL2.VS == '1' then
                return VTTBR_EL2.VMID;
            else
                return ZeroExtend(VTTBR_EL2.VMID<7:0>, 16);
        else
            return ZeroExtend(VTTBR.VMID, 16);
    elsif HaveEL\(EL2\) && HaveSecureEL2Ext\(\) then
        return Zeros(16);
    else
        return VMID\_NONE;
```

## Library pseudocode for aarch64/instrs/system/sysops/tlbi/VMID\_NONE

```
constant bits(16) VMID_NONE = Zeros();
```

## Library pseudocode for aarch64/instrs/vector/arithmetic/binary/uniform/logical/bsl-eor/vbitop/VBitOp

```
enumeration VBitOp {VBitOp_VBIF, VBitOp_VBIT, VBitOp_VBSL, VBitOp_VEOR};
```

## Library pseudocode for aarch64/instrs/vector/arithmetic/unary/cmp/compareop/CompareOp

```
enumeration CompareOp {CompareOp_GT, CompareOp_GE, CompareOp_EQ,
    CompareOp_LE, CompareOp_LT};
```

## Library pseudocode for aarch64/instrs/vector/logical/immediateop/ImmediateOp

```
enumeration ImmediateOp {ImmediateOp_MOVI, ImmediateOp_MVNI,
    ImmediateOp_ORR, ImmediateOp_BIC};
```

## Library pseudocode for aarch64/instrs/vector/reduce/reduceop/Reduce

```
// Reduce()
// =====

bits(esize) Reduce(ReduceOp op, bits(N) input, integer esize)
    boolean altfp = HaveAltFP() && !UsingAArch32() && FPCR.AH == '1';
    return Reduce(op, input, esize, altfp);

// Reduce()
// =====
// Perform the operation 'op' on pairs of elements from the input vector,
// reducing the vector to a scalar result. The 'altfp' argument controls
// alternative floating-point behaviour.

bits(esize) Reduce(ReduceOp op, bits(N) input, integer esize, boolean altfp)
    integer half;
    bits(esize) hi;
    bits(esize) lo;
    bits(esize) result;

    if N == esize then
        return input<esize-1:0>;

    half = N DIV 2;
    hi = Reduce(op, input<N-1:half>, esize, altfp);
    lo = Reduce(op, input<half-1:0>, esize, altfp);

    case op of
        when ReduceOp_FMINNUM
            result = FPMINum(lo, hi, FPCR[]);
        when ReduceOp_FMAXNUM
            result = FPMaxNum(lo, hi, FPCR[]);
        when ReduceOp_FMIN
            result = FPMIN(lo, hi, FPCR[], altfp);
        when ReduceOp_FMAX
            result = FPMax(lo, hi, FPCR[], altfp);
        when ReduceOp_FADD
            result = FPAdd(lo, hi, FPCR[]);
        when ReduceOp_ADD
            result = lo + hi;

    return result;
```

## Library pseudocode for aarch64/instrs/vector/reduce/reduceop/ReduceOp

```
enumeration ReduceOp {ReduceOp_FMINNUM, ReduceOp_FMAXNUM,
    ReduceOp_FMIN, ReduceOp_FMAX,
    ReduceOp_FADD, ReduceOp_ADD};
```

## Library pseudocode for aarch64/translation/debug/AArch64.CheckBreakpoint

```
// AArch64.CheckBreakpoint()
// =====
// Called before executing the instruction of length "size" bytes at "vaddress" in an AArch64
// translation regime, when either debug exceptions are enabled, or halting debug is enabled
// and halting is allowed.

FaultRecord AArch64.CheckBreakpoint(bits(64) vaddress, AccType acctype, integer size)
    assert !ELUsingAArch32\(S1TranslationRegime\(\)\);
    assert (UsingAArch32\(\) && size IN {2,4}) || size == 4;

    match = FALSE;

    for i = 0 to UInt(ID_AA64DFR0_EL1.BRPs)
        match_i = AArch64.BreakpointMatch(i, vaddress, acctype, size);
        match = match || match_i;

    if match && HaltOnBreakpointOrWatchpoint\(\) then
        reason = DebugHalt\_Breakpoint;
        Halt(reason);
    elseif match then
        acctype = AccType\_IFETCH;
        iswrite = FALSE;
        return AArch64.DebugFault(acctype, iswrite);
    else
        return NoFault();
```

## Library pseudocode for aarch64/translation/debug/AArch64.CheckDebug

```
// AArch64.CheckDebug()
// =====
// Called on each access to check for a debug exception or entry to Debug state.

FaultRecord AArch64.CheckDebug(bits(64) vaddress, AccType acctype, boolean iswrite, integer size)

    FaultRecord fault = NoFault();

    d_side = (acctype != AccType\_IFETCH);
    if HaveNV2Ext\(\) && acctype == AccType\_NV2REGISTER then
        mask = '0';
        generate_exception = AArch64.GenerateDebugExceptionsFrom(EL2, IsSecure\(\), mask) && MDSCR_EL1.MDE
    else
        generate_exception = AArch64.GenerateDebugExceptions() && MDSCR_EL1.MDE == '1';
    halt = HaltOnBreakpointOrWatchpoint\(\);

    if generate_exception || halt then
        if d_side then
            fault = AArch64.CheckWatchpoint(vaddress, acctype, iswrite, size);
        else
            fault = AArch64.CheckBreakpoint(vaddress, acctype, size);

    return fault;
```

## Library pseudocode for aarch64/translation/debug/AArch64.CheckWatchpoint

```
// AArch64.CheckWatchpoint()
// =====
// Called before accessing the memory location of "size" bytes at "address",
// when either debug exceptions are enabled for the access, or halting debug
// is enabled and halting is allowed.

FaultRecord AArch64.CheckWatchpoint(bits(64) vaddress, AccType acctype,
                                     boolean iswrite, integer size)
    assert !ELUsingAArch32(S1TranslationRegime());

    if acctype IN {AccType_TTW, AccType_IC, AccType_AT, AccType_ATPAN} then
        return NoFault();
    if acctype == AccType_DC then
        if !iswrite then
            return NoFault();

    match = FALSE;
    match_on_read = FALSE;
    ispriv = AArch64.AccessUsesEL(acctype) != EL0;

    for i = 0 to UInt(ID_AA64DFR0_EL1.WRPs)
        if AArch64.WatchpointMatch(i, vaddress, size, ispriv, acctype, iswrite) then
            match = TRUE;
            if DBGWCR_EL1[i].LSC<0> == '1' then
                match_on_read = TRUE;

    if match && acctype == AccType_ATOMICRW then
        iswrite = !match_on_read;

    if match && HaltOnBreakpointOrWatchpoint() then
        if acctype != AccType_NONFAULT && acctype != AccType_CNOTFIRST then
            reason = DebugHalt_Watchpoint;
            EDWAR = vaddress;
            Halt(reason);
        else
            // Fault will be reported and cancelled
            return AArch64.DebugFault(acctype, iswrite);
    elsif match then
        return AArch64.DebugFault(acctype, iswrite);
    else
        return NoFault();
```

## Library pseudocode for aarch64/translation/vmsa\_addrcalc/AArch64.BlockBase

```
// AArch64.BlockBase()
// =====
// Extract the address embedded in a block descriptor pointing to the base of
// a memory block

bits(52) AArch64.BlockBase(bits(64) descriptor, bit ds, TGx tgx, integer level)
    bits(52) blockbase = Zeros();

    if tgx == TGx\_4KB && level == 2 then
        blockbase<47:21> = descriptor<47:21>;
    elsif tgx == TGx\_4KB && level == 1 then
        blockbase<47:30> = descriptor<47:30>;
    elsif tgx == TGx\_4KB && level == 0 then
        blockbase<47:39> = descriptor<47:39>;
    elsif tgx == TGx\_16KB && level == 2 then
        blockbase<47:25> = descriptor<47:25>;
    elsif tgx == TGx\_16KB && level == 1 then
        blockbase<47:36> = descriptor<47:36>;
    elsif tgx == TGx\_64KB && level == 2 then
        blockbase<47:29> = descriptor<47:29>;
    elsif tgx == TGx\_64KB && level == 1 then
        blockbase<47:42> = descriptor<47:42>;
    else
        Unreachable();

    if Have52BitPAExt() && tgx == TGx\_64KB then
        blockbase<51:48> = descriptor<15:12>;
    elsif ds == '1' then
        blockbase<51:48> = descriptor<9:8>;descriptor<49:48>;

    return blockbase;
```

## Library pseudocode for aarch64/translation/vmsa\_addrcalc/AArch64.IASize

```
// AArch64.IASize()
// =====
// Retrieve the number of bits containing the input address

integer AArch64.IASize(bits(6) txsz)
    return 64 - UInt(txsz);
```

## Library pseudocode for aarch64/translation/vmsa\_addrcalc/AArch64.NextTableBase

```
// AArch64.NextTableBase()
// =====
// Extract the address embedded in a table descriptor pointing to the base of
// the next level table of descriptors

bits(52) AArch64.NextTableBase(bits(64) descriptor, bit ds, TGx tgx)
    bits(52) tablebase = Zeros();

    case tgx of
        when TGx\_4KB tablebase<47:12> = descriptor<47:12>;
        when TGx\_16KB tablebase<47:14> = descriptor<47:14>;
        when TGx\_64KB tablebase<47:16> = descriptor<47:16>;

    if Have52BitPAExt() && tgx == TGx\_64KB then
        tablebase<51:48> = descriptor<15:12>;
    elsif ds == '1' then
        tablebase<51:48> = descriptor<9:8>;descriptor<49:48>;

    return tablebase;
```

## Library pseudocode for aarch64/translation/vmsa\_addrcalc/AArch64.PageBase

```
// AArch64.PageBase()
// =====
// Extract the address embedded in a page descriptor pointing to the base of
// a memory page

bits(52) AArch64.PageBase(bits(64) descriptor, bit ds, TGx tgx)
    bits(52) pagebase = Zeros\(\);

    case tgx of
        when TGx\_4KB    pagebase<47:12> = descriptor<47:12>;
        when TGx\_16KB   pagebase<47:14> = descriptor<47:14>;
        when TGx\_64KB   pagebase<47:16> = descriptor<47:16>;

    if Have52BitPAExt\(\) && tgx == TGx\_64KB then
        pagebase<51:48> = descriptor<15:12>;
    elsif ds == '1' then
        pagebase<51:48> = descriptor<9:8>:descriptor<49:48>;

    return pagebase;
```

## Library pseudocode for aarch64/translation/vmsa\_addrcalc/AArch64.PhysicalAddressSize

```
// AArch64.PhysicalAddressSize()
// =====
// Retrieve the number of bits bounding the physical address

integer AArch64.PhysicalAddressSize(bits(3) encoded_ps, TGx tgx)
    integer ps;

    case encoded_ps of
        when '000' ps = 32;
        when '001' ps = 36;
        when '010' ps = 40;
        when '011' ps = 42;
        when '100' ps = 44;
        when '101' ps = 48;
        when '110' ps = 52;
        otherwise
            ps = integer IMPLEMENTATION_DEFINED "Reserved Intermediate Physical Address size value";

    if tgx != TGx\_64KB && !Have52BitIPAAndPASpaceExt\(\) then
        max_ps = Min(48, AArch64.PAMax\(\));
    else
        max_ps = AArch64.PAMax\(\);

    return Min(ps, max_ps);
```

## Library pseudocode for aarch64/translation/vmsa\_addrcalc/AArch64.S1StartLevel

```
// AArch64.S1StartLevel()
// =====
// Compute the initial lookup level when performing a stage 1 translation
// table walk

integer AArch64.S1StartLevel(S1TTWParams walkparams)
    // Input Address size
    iasize = AArch64.IASize(walkparams.txsz);
    granulebits = TGxGranuleBits(walkparams.tgx);
    stride = granulebits - 3;

    return FINAL\_LEVEL - (((iasize-1) - granulebits) DIV stride);
```

## Library pseudocode for aarch64/translation/vmsa\_addrcalc/AArch64.S2SLTTEntryAddress

```
// AArch64.S2SLTTEntryAddress()
// =====
// Compute the first stage 2 translation table descriptor address within the
// table pointed to by the base at the start level

FullAddress AArch64.S2SLTTEntryAddress(S2TTWParams walkparams, bits(52) ipa,
                                       FullAddress tablebase)
    startlevel = AArch64.S2StartLevel(walkparams);
    iasize     = AArch64.IASize(walkparams.txsz);
    granulebits = TGxGranuleBits(walkparams.tgx);
    stride     = granulebits - 3;
    levels     = FINAL\_LEVEL - startlevel;

    bits(52) index;
    lsb  = levels*stride + granulebits;
    msb  = iasize - 1;
    index = ZeroExtend(ipa<msb:lsb>:Zeros(3));

    FullAddress descaddress;
    descaddress.address = tablebase.address OR index;
    descaddress.paspace = tablebase.paspace;

    return descaddress;
```

## Library pseudocode for aarch64/translation/vmsa\_addrcalc/AArch64.S2StartLevel

```
// AArch64.S2StartLevel()
// =====
// Determine the initial lookup level when performing a stage 2 translation
// table walk

integer AArch64.S2StartLevel(S2TTWParams walkparams)
    case walkparams.tgx of
        when TGx\_4KB
            case walkparams.sl2:walkparams.sl0 of
                when '000' return 2;
                when '001' return 1;
                when '010' return 0;
                when '011' return 3;
                when '100' return -1;
        when TGx\_16KB
            case walkparams.sl0 of
                when '00' return 3;
                when '01' return 2;
                when '10' return 1;
                when '11' return 0;
        when TGx\_64KB
            case walkparams.sl0 of
                when '00' return 3;
                when '01' return 2;
                when '10' return 1;
```

## Library pseudocode for aarch64/translation/vmsa\_addrcalc/AArch64.TTBaseAddress

```
// AArch64.TTBaseAddress()
// =====
// Retrieve the PA/IPA pointing to the base of the initial translation table

bits(52) AArch64.TTBaseAddress(bits(64) ttb, bits(6) txsz, bits(3) ps,
                                bit ds, TGx tgx, integer startlevel)
    bits(52) tablebase = Zeros();

    // Input Address size
    iasize      = AArch64.IASize(txsz);
    granulebits = TGxGranuleBits(tgx);
    stride      = granulebits - 3;
    levels      = FINAL\_LEVEL - startlevel;

    // Base address is aligned to size of the initial translation table in bytes
    tsize = iasize - (levels*stride + granulebits) + 3;

    if (Have52BitPAExt() && tgx == TGx\_64KB && ps == '110') || (ds == '1') then
        tsize = Max(tsize, 6);
        tablebase<51:6> = ttb<5:2>:ttb<47:6>;
    else
        tablebase<47:1> = ttb<47:1>;

    tablebase = Align(tablebase, 1 << tsize);
    return tablebase;
```

## Library pseudocode for aarch64/translation/vmsa\_addrcalc/AArch64.TTEntryAddress

```
// AArch64.TTEntryAddress()
// =====
// Compute translation table descriptor address within the table pointed to by
// the table base

FullAddress AArch64.TTEntryAddress(integer level, TGx tgx, bits(6) txsz,
                                    bits(64) ia, FullAddress tablebase)
    // Input Address size
    iasize      = AArch64.IASize(txsz);
    granulebits = TGxGranuleBits(tgx);
    stride      = granulebits - 3;
    levels      = FINAL\_LEVEL - level;

    bits(52) index;
    lsb      = levels*stride + granulebits;
    msb      = Min(iasize - 1, lsb + stride - 1);
    index = ZeroExtend(ia<msb:lsb>:Zeros(3));

    FullAddress descaddress;
    descaddress.address = tablebase.address OR index;
    descaddress.paspace = tablebase.paspace;

    return descaddress;
```



### Library pseudocode for aarch64/translation/vmsa\_faults/AArch64.AddrTop

```
// AArch64.AddrTop()
// =====
// Get the top bit position of the virtual address.
// Bits above are not accounted as part of the translation process.

integer AArch64.AddrTop(bit tbid, AccType acctype, bit tbi)
    if tbid == '1' && acctype == AccType_IFETCH then
        return 63;

    if tbi == '1' then
        return 55;
    else
        return 63;
```

### Library pseudocode for aarch64/translation/vmsa\_faults/AArch64.ContiguousBitFaults

```
// AArch64.ContiguousBitFaults()
// =====
// If contiguous bit is set, returns whether the translation size exceeds the
// input address size and if the implementation generates a fault

boolean AArch64.ContiguousBitFaults(bits(6) txsz, TGx tgx, integer level)
    // Input Address size
    iasize = AArch64.IASize(txsz);
    // Translation size
    tsize = TranslationSize(tgx, level) + AArch64.ContiguousSizeLog2(tgx, level);

    fault = boolean IMPLEMENTATION_DEFINED "Translation fault on misprogrammed contiguous bit";

    return tsize > iasize && fault;
```

### Library pseudocode for aarch64/translation/vmsa\_faults/AArch64.DebugFault

```
// AArch64.DebugFault()
// =====
// Return a fault record indicating a hardware watchpoint/breakpoint

FaultRecord AArch64.DebugFault(AccType acctype, boolean iswrite)
    FaultRecord fault;

    fault.statuscode = Fault_Debug;
    fault.acctype = acctype;
    fault.write = iswrite;
    fault.secondstage = FALSE;
    fault.s2fslwalk = FALSE;

    return fault;
```

### Library pseudocode for aarch64/translation/vmsa\_faults/AArch64.ExclusiveFault

```
// AArch64.ExclusiveFault()
// =====

FaultRecord AArch64.ExclusiveFault(AccType acctype, boolean iswrite,
                                    boolean secondstage, boolean s2fslwalk)
    FaultRecord fault;

    fault.statuscode = Fault_Exclusive;
    fault.acctype = acctype;
    fault.write = iswrite;
    fault.secondstage = secondstage;
    fault.s2fslwalk = s2fslwalk;

    return fault;
```

### Library pseudocode for aarch64/translation/vmsa\_faults/AArch64.IPAIsOutOfRange

```
// AArch64.IPAIsOutOfRange()
// =====
// Check bits not resolved by translation are ZERO

boolean AArch64.IPAIsOutOfRange(bits(52) ipa, S2TTWParams walkparams)
    //Input Address size
    iasize = AArch64.IASize(walkparams.txsz);

    if iasize < 52 then
        return !IsZero(ipa<51:iasize>);
    else
        return FALSE;
```

### Library pseudocode for aarch64/translation/vmsa\_faults/AArch64.OAOutOfRange

```
// AArch64.OAOutOfRange()
// =====
// Returns whether output address is expressed in the configured size number of bits

boolean AArch64.OAOutOfRange(TTWState walkstate, bits(3) ps, TGx tgx)
    // Output Address size
    oasize = AArch64.PhysicalAddressSize(ps, tgx);
    baseaddress = walkstate.baseaddress.address;

    if oasize < 52 then
        return !IsZero(baseaddress<51:oasize>);
    else
        return FALSE;
```

### Library pseudocode for aarch64/translation/vmsa\_faults/AArch64.S1HasAlignmentFault

```
// AArch64.S1HasAlignmentFault()
// =====
// Returns whether stage 1 output fails alignment requirement on data accesses
// to Device memory

boolean AArch64.S1HasAlignmentFault(AccType acctype, boolean aligned,
                                     bit ntlsmid, MemoryAttributes memattrs)
    if acctype == AccType\_IFETCH || memattrs.memtype != MemType\_Device then
        return FALSE;

    if acctype == AccType\_A32LSMD && ntlsmid == '0' && memattrs.device != DeviceType\_GRE then
        return TRUE;

    return !aligned || acctype == AccType\_DCZVA;
```



```

// AArch64.S1HasPermissionsFault()
// =====
// Returns whether stage 1 access violates permissions of target memory

boolean AArch64.S1HasPermissionsFault(Regime regime, TTWState walkstate,
                                       S1TTWParams walkparams, boolean ispriv,
                                       AccType acctype, boolean iswrite)
permissions = walkstate.permissions;

if HasUnprivileged(regime) then
    // Apply leaf permissions
    case permissions.ap<2:1> of
        when '00' (pr,pw,ur,uw) = ('1','1','0','0'); // Privileged access
        when '01' (pr,pw,ur,uw) = ('1','1','1','1'); // No effect
        when '10' (pr,pw,ur,uw) = ('1','0','0','0'); // Read-only, privileged access
        when '11' (pr,pw,ur,uw) = ('1','0','1','0'); // Read-only

    // Apply hierarchical permissions
    case permissions.ap_table of
        when '00' (pr,pw,ur,uw) = ( pr, pw, ur, uw); // No effect
        when '01' (pr,pw,ur,uw) = ( pr, pw,'0','0'); // Privileged access
        when '10' (pr,pw,ur,uw) = ( pr,'0', ur,'0'); // Read-only
        when '11' (pr,pw,ur,uw) = ( pr,'0','0','0'); // Read-only, privileged access

    // Locations writable by unprivileged cannot be executed by privileged
    px = NOT(permissions.pxn OR permissions.pxn_table OR uw);
    ux = NOT(permissions.uxn OR permissions.uxn_table);

    pan_access = !(acctype IN {AccType\_DC, AccType\_IFETCH, AccType\_AT, AccType\_NV2REGISTER});
    if HavePANExt() && pan_access && !(PSTATE.EL == EL1 && walkparams.nv1 == '1') then
        pan = PSTATE.PAN AND (ur OR uw OR (walkparams.epan AND ux));
        pr = pr AND NOT(pan);
        pw = pw AND NOT(pan);

    (r,w,x) = if ispriv then (pr,pw,px) else (ur,uw,ux);
else
    // Apply leaf permissions
    case permissions.ap<2> of
        when '0' (r,w) = ('1','1'); // No effect
        when '1' (r,w) = ('1','0'); // Read-only

    // Apply hierarchical permissions
    case permissions.ap_table<1> of
        when '0' (r,w) = ( r , w ); // No effect
        when '1' (r,w) = ( r ,'0'); // Read-only

    x = NOT(permissions.xn OR permissions.xn_table);

// Prevent execution from writable locations if WXN is set
x = x AND NOT(walkparams.wxn AND w);

// Prevent execution from Non-secure space by PE in secure state if SIF is set
if (AArch64.CurrentSecurityState() == SS\_Secure &&
    walkstate.baseaddress.paspace == PAS_NonSecure) then
    x = x AND NOT(walkparams.sif);

if acctype == AccType\_IFETCH then
    if (ConstrainUnpredictable(Unpredictable\_INSTRDEVICE) == Constraint\_FAULT &&
        walkstate.memattrs.memtype == MemType\_Device) then
        return TRUE;

    return x == '0';
elseif acctype == AccType\_DC then
    if iswrite then
        return w == '0';
    else
        // DC from privileged context which do no write cannot permission fault
        return !ispriv && r == '0';
elseif acctype == AccType\_IC then
    // IC instructions do not write

```

```

    assert !iswrite;
    impdef_ic_fault = boolean IMPLEMENTATION_DEFINED "Permission fault on EL0 IC_IVAU execution";

    // IC from privileged context cannot permission fault
    return !ispriv && r == '0' && impdef_ic_fault;
elseif iswrite then
    return w == '0';
else
    return r == '0';

```

### Library pseudocode for aarch64/translation/vmsa\_faults/AArch64.S1InvalidTxSZ

```

// AArch64.S1InvalidTxSZ()
// =====
// Detect erroneous configuration of stage 1 TxSZ field if the implementation
// does not constrain the value of TxSZ

boolean AArch64.S1InvalidTxSZ(S1TTWParams walkparams)
    mintxs = AArch64.S1MinTxSZ(walkparams.ds, walkparams.tgx);
    maxtxsz = AArch64.MaxTxSZ(walkparams.tgx);

    return UInt(walkparams.txsz) < mintxs || UInt(walkparams.txsz) > maxtxsz;

```

### Library pseudocode for aarch64/translation/vmsa\_faults/AArch64.S2HasAlignmentFault

```

// AArch64.S2HasAlignmentFault()
// =====
// Returns whether stage 2 output fails alignment requirement on data accesses
// to Device memory

boolean AArch64.S2HasAlignmentFault(AccType acctype, boolean aligned,
                                     MemoryAttributes memattrs)
    if acctype == AccType\_IFETCH || memattrs.memtype != MemType\_Device then
        return FALSE;

    return !aligned || acctype == AccType\_DCZVA;

```

## Library pseudocode for aarch64/translation/vmsa\_faults/AArch64.S2HasPermissionsFault

```
// AArch64.S2HasPermissionsFault()
// =====
// Returns whether stage 2 access violates permissions of target memory

boolean AArch64.S2HasPermissionsFault(boolean s2fslwalk, TTWState walkstate,
                                       S2TTWParams walkparams, boolean ispriv,
                                       AccType acctype, boolean iswrite)

permissions = walkstate.permissions;
memtype = walkstate.memattrs.memtype;

r = permissions.s2ap<0>;
w = permissions.s2ap<1>;

case (permissions.s2xn:permissions.s2xnx) of
  when '00' (px,ux) = ('1','1');
  when '01' (px,ux) = ('0','1');
  when '10' (px,ux) = ('0','0');
  when '11' (px,ux) = ('1','0');

x = if ispriv then px else ux;

if s2fslwalk && walkparams.ptw == '1' && memtype == MemType_Device then
  return TRUE;
elsif acctype == AccType_IFETCH then
  constraint = ConstrainUnpredictable(Unpredictable_INSTRDEVICE);
  if constraint == Constraint_FAULT && memtype == MemType_Device then
    return TRUE;
  return x == '0';
elsif acctype == AccType_DC then
  // AArch32 DC maintenance instructions operating by VA cannot fault.
  if iswrite then
    return !UsingAArch32() && w == '0';
  else
    // DC from privileged context which do no write cannot permission fault
    return !UsingAArch32() && !ispriv && r == '0';
elsif acctype == AccType_IC then
  // IC instructions do not write
  assert !iswrite;
  impdef_ic_fault = boolean IMPLEMENTATION_DEFINED "Permission fault on EL0 IC_IVAU execution";

  // AArch32 IC maintenance instructions operating by VA cannot fault.
  // IC from privileged context cannot permission fault
  return !UsingAArch32() && !ispriv && r == '0' && impdef_ic_fault;
elsif iswrite then
  return w == '0';
else
  return r == '0';
```

## Library pseudocode for aarch64/translation/vmsa\_faults/AArch64.S2InconsistentSL

```
// AArch64.S2InconsistentSL()
// =====
// Detect inconsistent configuration of stage 2 TxSZ and SL fields

boolean AArch64.S2InconsistentSL(S2TTWParams walkparams)
    startlevel = AArch64.S2StartLevel(walkparams);
    levels     = FINAL\_LEVEL - startlevel;
    granulebits = TGxGranuleBits(walkparams.tgx);
    stride     = granulebits - 3;

    // Input address size must at least be large enough to be resolved from the start level
    sl_min_iasize = (
        levels * stride // Bits resolved by table walk, except initial level
        + granulebits   // Bits directly mapped to output address
        + 1);          // At least 1 more bit to be decoded by initial level

    // Can accomodate 1 more stride in the level + concatenation of up to 2^4 tables
    sl_max_iasize = sl_min_iasize + (stride-1) + 4;
    // Configured Input Address size
    iasize       = AArch64.IASize(walkparams.txsz);

    return iasize < sl_min_iasize || iasize > sl_max_iasize;
```

## Library pseudocode for aarch64/translation/vmsa\_faults/AArch64.S2InvalidSL

```
// AArch64.S2InvalidSL()
// =====
// Detect invalid configuration of SL field

boolean AArch64.S2InvalidSL(S2TTWParams walkparams)
    case walkparams.tgx of
        when TGx\_4KB
            case walkparams.sl2:walkparams.sl0 of
                when '1x1' return TRUE;
                when '11x' return TRUE;
                when '010' return AArch64.PAMax() < 44;
                when '011' return !HaveSmallTranslationTableExt();
                otherwise return FALSE;
        when TGx\_16KB
            case walkparams.ds:walkparams.sl0 of
                when '011' return TRUE;
                when '010' return AArch64.PAMax() < 42;
                otherwise return FALSE;
        when TGx\_64KB
            case walkparams.sl0 of
                when '11' return TRUE;
                when '10' return AArch64.PAMax() < 44;
                otherwise return FALSE;
```

## Library pseudocode for aarch64/translation/vmsa\_faults/AArch64.S2InvalidTxSZ

```
// AArch64.S2InvalidTxSZ()
// =====
// Detect erroneous configuration of stage 2 TxSZ field if the implementation
// does not constrain the value of TxSZ

boolean AArch64.S2InvalidTxSZ(S2TTWParams walkparams, boolean slaarch64)
    mintxs = AArch64.S2MinTxSZ(walkparams.ds, walkparams.tgx, slaarch64);
    maxtxs = AArch64.MaxTxSZ(walkparams.tgx);

    return UInt(walkparams.txsz) < mintxs || UInt(walkparams.txsz) > maxtxs;
```

## Library pseudocode for aarch64/translation/vmsa\_faults/AArch64.VAIsOutOfRange

```
// AArch64.VAIsOutOfRange()
// =====
// Check bits not resolved by translation are identical and of accepted value

boolean AArch64.VAIsOutOfRange(bits(64) va, AccType acctype, Regime regime,
                                S1TTWParams walkparams)
    addrtop = AArch64.AddrTop(walkparams.tbid, acctype, walkparams.tbi);
    // Input Address size
    iasize = AArch64.IASize(walkparams.txsz);

    if HasUnprivileged(regime) then
        if AArch64.GetVARange(va) == VARange\_LOWER then
            return !IsZero(va<addrtop:iasize>);
        else
            return !IsOnes(va<addrtop:iasize>);
    else
        return !IsZero(va<addrtop:iasize>);
```

## Library pseudocode for aarch64/translation/vmsa\_memattr/AArch64.IsS2ResultTagged

```
// AArch64.IsS2ResultTagged()
// =====
// Determine whether the combined output memory attributes of stage 1 and
// stage 2 indicate tagged memory

boolean AArch64.IsS2ResultTagged(MemoryAttributes s2_memattrs, boolean s1_tagged)
    return (
        s1_tagged
        (s2_memattrs.memtype == MemType\_Normal) &&
        (s2_memattrs.inner.attrs == MemAttr\_WB) &&
        (s2_memattrs.inner.hints == MemHint\_RWA) &&
        (!s2_memattrs.inner.transient) &&
        (s2_memattrs.outer.attrs == MemAttr\_WB) &&
        (s2_memattrs.outer.hints == MemHint\_RWA) &&
        (!s2_memattrs.outer.transient)
    );
```



## Library pseudocode for aarch64/translation/vmsa\_memattr/AArch64.S2ApplyFWBMemAttrs

```
// AArch64.S2ApplyFWBMemAttrs()
// =====
// Apply stage 2 forced Write-Back on stage 1 memory attributes.

MemoryAttributes AArch64.S2ApplyFWBMemAttrs(MemoryAttributes s1_memattrs,
                                             bits(4) s2_attr, bits(2) s2_sh)
    MemoryAttributes memattrs;

    if s2_attr<2> == '0' then          // S2 Device, S1 any
        s2_device = DecodeDevice(s2_attr<1:0>);
        memattrs.memtype = MemType_Device;
        memattrs.shareability = Shareability_OSH;
        if s1_memattrs.memtype == MemType_Device then
            memattrs.device = S2CombineS1Device(s1_memattrs.device, s2_device);
        else
            memattrs.device = s2_device;
    elseif s2_attr<1:0> == '11' then  // S2 attr = S1 attr
        memattrs = s1_memattrs;
        s2_shareability = DecodeShareability(s2_sh);
        memattrs.shareability = S2CombineS1Shareability(s1_memattrs.shareability,
                                                         s2_shareability);
    elseif s2_attr<1:0> == '10' then  // Force writeback
        memattrs.memtype = MemType_Normal;
        memattrs.inner.attrs = MemAttr_WB;
        memattrs.outer.attrs = MemAttr_WB;

        if (s1_memattrs.memtype == MemType_Normal &&
            s1_memattrs.inner.attrs != MemAttr_NC) then
            memattrs.inner.hints = s1_memattrs.inner.hints;
            memattrs.inner.transient = s1_memattrs.inner.transient;
        else
            memattrs.inner.hints = MemHint_RWA;
            memattrs.inner.transient = FALSE;

        if (s1_memattrs.memtype == MemType_Normal &&
            s1_memattrs.outer.attrs != MemAttr_NC) then
            memattrs.outer.hints = s1_memattrs.outer.hints;
            memattrs.outer.transient = s1_memattrs.outer.transient;
        else
            memattrs.outer.hints = MemHint_RWA;
            memattrs.outer.transient = FALSE;

        s2_shareability = DecodeShareability(s2_sh);
        memattrs.shareability = S2CombineS1Shareability(s1_memattrs.shareability,
                                                         s2_shareability);
    else                               // Non-cacheable unless S1 is device
        if s1_memattrs.memtype == MemType_Device then
            memattrs = s1_memattrs;
        else
            MemAttrHints cacheability_attr;
            cacheability_attr.attrs = MemAttr_NC;

            memattrs.memtype = MemType_Normal;
            memattrs.inner = cacheability_attr;
            memattrs.outer = cacheability_attr;

            memattrs.shareability = Shareability_OSH;

    memattrs.tagged = AArch64.IsS2ResultTagged(memattrs, s1_memattrs.tagged);

    return memattrs;
```

## Library pseudocode for aarch64/translation/vmsa\_translation/AArch64.AccessUsesEL

```
// AArch64.AccessUsesEL()
// =====
// Returns the Exception Level of the regime that will manage the translation for a given access type.

bits(2) AArch64.AccessUsesEL(AccType acctype)
    if acctype == AccType_UNPRIV then
        return EL0;
    elsif acctype == AccType_NV2REGISTER then
        return EL2;
    else
        return PSTATE.EL;
```

## Library pseudocode for aarch64/translation/vmsa\_translation/AArch64.FaultAllowsSetAccessFlag

```
// AArch64.FaultAllowsSetAccessFlag()
// =====
// Determine whether the access flag could be set by HW given the fault status

boolean AArch64.FaultAllowsSetAccessFlag(FaultRecord fault)
    if fault.statuscode == Fault_None then
        return TRUE;
    elsif fault.statuscode IN {Fault_Alignment, Fault_Permission} then
        return ConstrainUnpredictable(Unpredictable_AFUPDATE) == Constraint_TRUE;
    else
        return FALSE;
```

## Library pseudocode for aarch64/translation/vmsa\_translation/AArch64.FullTranslate

```
// AArch64.FullTranslate()
// =====
// Address translation as specified by VMSA
// Alignment check NOT due to memory type is expected to be done before translation

AddressDescriptor AArch64.FullTranslate(bits(64) va, AccType acctype,
                                         boolean iswrite, boolean aligned)

    fault = NoFault();
    fault.acctype = acctype;
    fault.write = iswrite;

    regime = TranslationRegime(PSTATE.EL, acctype);

    (fault, ipa) = AArch64.S1Translate(fault, regime, va, acctype, aligned, iswrite);

    if fault.statuscode != Fault_None then
        return CreateFaultyAddressDescriptor(va, fault);

    if regime == Regime_EL10 && EL2Enabled() then
        slaarch64 = TRUE;
        s2fslwalk = FALSE;
        (fault, pa) = AArch64.S2Translate(fault, ipa, slaarch64, s2fslwalk,
                                          acctype, aligned, iswrite);

        if fault.statuscode != Fault_None then
            return CreateFaultyAddressDescriptor(va, fault);
        else
            return pa;
    else
        return ipa;
```

## Library pseudocode for aarch64/translation/vmsa\_translation/AArch64.MemSwapTableDesc

```
// AArch64.MemSwapTableDesc()
// =====
// Perform HW update of table descriptor as an atomic operation

(FaultRecord, bits(64)) AArch64.MemSwapTableDesc(FaultRecord fault,
                                                    bits(64) prev_desc, bits(64) new_desc, bit ee,
                                                    AddressDescriptor descupdateaddress)
    descupdateaccess = CreateAccessDescriptor(AccType\_ATOMICRW);

    if ee == '1' then
        new_desc = BigEndianReverse(new_desc);
        prev_desc = BigEndianReverse(prev_desc);

    // All observers in the shareability domain observe the
    // following memory read and write accesses atomically.
    mem_desc = _Mem[descupdateaddress, 8, descupdateaccess, FALSE];
    if mem_desc == prev_desc then
        _Mem[descupdateaddress, 8, descupdateaccess] = new_desc;
        mem_desc = new_desc;

    if ee == '1' then
        mem_desc = BigEndianReverse(mem_desc);

    assert mem_desc == new_desc;

    return (fault, mem_desc);
```

## Library pseudocode for aarch64/translation/vmsa\_translation/AArch64.S1DisabledOutput

```
// AArch64.S1DisabledOutput()
// =====
// Map the the VA to IPA/PA and assign default memory attributes

(FaultRecord, AddressDescriptor) AArch64.S1DisabledOutput(FaultRecord fault,
    Regime regime, bits(64) va, AccType acctype, boolean aligned)

    walkparams = AArch64.GetS1TTWParams(regime, va);

    // No memory page is guarded when stage 1 address translation is disabled
    SetInGuardedPage(FALSE);

    // Output Address
    FullAddress oa;
    oa.address = va<51:0>;
    case AArch64.CurrentSecurityState() of
        when SS\_Secure    oa.paspace = PAS_Secure;
        when SS\_NonSecure oa.paspace = PAS_NonSecure;

    MemoryAttributes memattrs;
    if regime == Regime\_EL10 && EL2Enabled() && walkparams.dc == '1' then
        MemAttrHints default_cacheability;
        default_cacheability.attrs = MemAttr\_WB;
        default_cacheability.hints = MemHint\_RWA;
        default_cacheability.transient = FALSE;

        memattrs.memtype = MemType\_Normal;
        memattrs.outer = default_cacheability;
        memattrs.inner = default_cacheability;
        memattrs.shareability = Shareability\_NSH;
        memattrs.tagged = walkparams.dct == '1';
        memattrs.xs = '0';
    elseif acctype == AccType\_IFETCH then
        MemAttrHints i_cache_attr;
        if AArch64.S1ICacheEnabled(regime) then
            i_cache_attr.attrs = MemAttr\_WT;
            i_cache_attr.hints = MemHint\_RA;
            i_cache_attr.transient = FALSE;
        else
            i_cache_attr.attrs = MemAttr\_NC;

        memattrs.memtype = MemType\_Normal;
        memattrs.outer = i_cache_attr;
        memattrs.inner = i_cache_attr;
        memattrs.shareability = Shareability\_OSH;
        memattrs.tagged = FALSE;
        memattrs.xs = '1';
    else
        memattrs.memtype = MemType\_Device;
        memattrs.device = DeviceType\_nGnRnE;
        memattrs.shareability = Shareability\_OSH;
        memattrs.xs = '1';

    fault.level = 0;
    addrtop = AArch64.AddrTop(walkparams.tbid, acctype, walkparams.tbi);
    if !IsZero(va<addrtop:AArch64.PAMax()>) then
        fault.statuscode = Fault\_AddressSize;
    elseif AArch64.S1HasAlignmentFault(acctype, aligned, walkparams.ntlsmid, memattrs) then
        fault.statuscode = Fault\_Alignment;

    if fault.statuscode != Fault\_None then
        return (fault, AddressDescriptor UNKNOWN);
    else
        ipa = CreateAddressDescriptor(va, oa, memattrs);
        return (fault, ipa);
```



```

// AArch64.S1Translate()
// =====
// Translate VA to IPA/PA depending on the regime

(FaultRecord, AddressDescriptor) AArch64.S1Translate(FaultRecord fault,
    Regime regime, bits(64) va, AccType acctype, boolean aligned,
    boolean iswrite)

// Prepare fault fields in case a fault is detected
fault.secondstage = FALSE;
fault.s2fslwalk = FALSE;

if !AArch64.S1Enabled(regime) then
    return AArch64.S1DisabledOutput(fault, regime, va, acctype, aligned);

walkparams = AArch64.GetS1TTWParams(regime, va);

if (AArch64.VAIsOutOfRange(va, acctype, regime, walkparams) ||
    (AArch64.AccessUsesEL(acctype) == EL0 && walkparams.e0pd == '1')) then
    fault.statuscode = Fault_Translation;
    fault.level = 0;
    return (fault, AddressDescriptor UNKNOWN);

(fault, descaddress, walkstate,
    descriptor) = AArch64.S1Walk(fault, walkparams, va, regime, acctype,
    iswrite);

if fault.statuscode != Fault_None then
    return (fault, AddressDescriptor UNKNOWN);

ispriv = AArch64.AccessUsesEL(acctype) != EL0;

if acctype == AccType_IFETCH then
    // Flag the fetched instruction is from a guarded page
    SetInGuardedPage(walkstate.guardedpage == '1');

if AArch64.S1HasAlignmentFault(acctype, aligned, walkparams.ntlsmid,
    walkstate.memattrs) then
    fault.statuscode = Fault_Alignment;
elseif IsAtomicRW(acctype) then
    if AArch64.S1HasPermissionsFault(regime, walkstate, walkparams,
        ispriv, acctype, FALSE) then
        // The permission fault was not caused by lack of write permissions
        fault.statuscode = Fault_Permission;
        fault.write = FALSE;
    elseif AArch64.S1HasPermissionsFault(regime, walkstate, walkparams,
        ispriv, acctype, TRUE) then
        // The permission fault _was_ caused by lack of write permissions
        fault.statuscode = Fault_Permission;
        fault.write = TRUE;
elseif AArch64.S1HasPermissionsFault(regime, walkstate, walkparams,
    ispriv, acctype, iswrite) then
    fault.statuscode = Fault_Permission;

new_desc = descriptor;
if walkparams.ha == '1' && AArch64.FaultAllowsSetAccessFlag(fault) then
    // Set descriptor AF bit
    new_desc<10> = '1';

// If HW update of dirty bit is enabled, the walk state permissions
// will already reflect a configuration permitting writes.
// The update of the descriptor occurs only if the descriptor bits in
// memory do not reflect that and the access instigates a write.
if (fault.statuscode == Fault_None &&
    walkparams.ha == '1' &&
    walkparams.hd == '1' &&
    descriptor<51> == '1' && // Descriptor DBM bit
    (IsAtomicRW(acctype) || iswrite) &&
    !(acctype IN {AccType_AT, AccType_ATPAN, AccType_IC, AccType_DC})) then
    // Clear descriptor AP[2] bit permitting stage 1 writes

```

```

    new_desc<7> = '0';

// Either the access flag was clear or AP<2> is set
if new_desc != descriptor then
    if regime == Regime_EL10 && EL2Enabled() then
        slaarch64 = TRUE;
        s2fslwalk = TRUE;
        aligned    = TRUE;
        iswrite    = TRUE;
        (s2fault, descupdateaddress) = AArch64.S2Translate(fault, descaddress,
                                                            slaarch64, s2fslwalk, AccType_ATOMICRW,
                                                            aligned, iswrite);

        if s2fault.statuscode != Fault_None then
            return (s2fault, AddressDescriptor UNKNOWN);
    else
        descupdateaddress = descaddress;

    (fault, mem_desc) = AArch64.MemSwapTableDesc(fault, descriptor, new_desc,
                                                  walkparams.ee, descupdateaddress);

if fault.statuscode != Fault_None then
    return (fault, AddressDescriptor UNKNOWN);

// Output Address
oa = StageOA(walkstate.baseaddress, va, walkparams.tgx, walkstate.level);

if (acctype == AccType_IFETCH &&
    (walkstate.memattrs.memtype == MemType_Device || !AArch64.S1ICacheEnabled(regime))) then
    // Treat memory attributes as Normal Non-Cacheable
    memattrs = NormalNCMemAttr();
    memattrs.xs = walkstate.memattrs.xs;
elseif (acctype != AccType_IFETCH && !AArch64.S1DCacheEnabled(regime) &&
        walkstate.memattrs.memtype == MemType_Normal) then
    // Treat memory attributes as Normal Non-Cacheable
    memattrs = NormalNCMemAttr();
    memattrs.xs = walkstate.memattrs.xs;

    // The effect of SCTLR_ELx.C when '0' is Constrained UNPREDICTABLE
    // on the Tagged attribute
    if HaveMTE2Ext() && walkstate.memattrs.tagged then
        memattrs.tagged = ConstrainUnpredictableBool(Unpredictable_S1CTAGGED);
else
    memattrs = walkstate.memattrs;

if regime == Regime_EL10 && EL2Enabled() && HCR_EL2.VM == '1' then
    // Shareability of target memory subject to stage 2 translation
    // is maintained as input to stage 2
    memattrs.shareability = walkstate.memattrs.shareability;
elseif (memattrs.memtype == MemType_Device ||
        (memattrs.inner.attrs == MemAttr_NC && memattrs.outer.attrs == MemAttr_NC)) then
    // If the target memory is Device memory or is Normal memory
    // inner Non-Cacheable outer Non-Cacheable then it is forced to Outer Shareable
    memattrs.shareability = Shareability_OSH;

if acctype == AccType_ATOMICLS64 && memattrs.memtype == MemType_Normal then
    if memattrs.inner.attrs != MemAttr_NC || memattrs.outer.attrs != MemAttr_NC then
        fault.statuscode = Fault_Exclusive;
        return (fault, AddressDescriptor UNKNOWN);

ipa = CreateAddressDescriptor(va, oa, memattrs);
return (fault, ipa);

```





```

// AArch64.S2Translate()
// =====
// Translate stage 1 IPA to PA and combine memory attributes

(FaultRecord, AddressDescriptor) AArch64.S2Translate(FaultRecord fault,
    AddressDescriptor ipa, boolean slaarch64, boolean s2fslwalk,
    AccType acctype, boolean aligned, boolean iswrite)
    walkparams = AArch64.GetS2TTWParams(ipa.paddress.paspace, slaarch64);

    // Prepare fault fields in case a fault is detected
    fault.statuscode = Fault_None; // Ignore any faults from stage 1
    fault.secondstage = TRUE;
    fault.s2fslwalk = s2fslwalk;
    fault.ipaddress = ipa.paddress;

    if walkparams.vm != '1' then
        // Stage 2 translation is disabled
        fault.level = 0;
        if AArch64.S2HasAlignmentFault(acctype, aligned, ipa.memattrs) then
            fault.statuscode = Fault_Alignment;
            return (fault, AddressDescriptor UNKNOWN);
        else
            return (fault, ipa);

    if AArch64.IPAIsOutOfRange(ipa.paddress.address, walkparams) then
        fault.statuscode = Fault_Translation;
        fault.level = 0;
        return (fault, AddressDescriptor UNKNOWN);

    (fault, descaddress, walkstate,
        descriptor) = AArch64.S2Walk(fault, ipa, walkparams, acctype, iswrite,
            slaarch64);

    if fault.statuscode != Fault_None then
        return (fault, AddressDescriptor UNKNOWN);

    ispriv = AArch64.AccessUsesEL(acctype) != EL0;

    if AArch64.S2HasAlignmentFault(acctype, aligned, walkstate.memattrs) then
        fault.statuscode = Fault_Alignment;
    elseif IsAtomicRW(acctype) then
        if AArch64.S2HasPermissionsFault(s2fslwalk, walkstate, walkparams,
            ispriv, acctype, FALSE) then
            // The permission fault was not caused by lack of write permissions
            fault.statuscode = Fault_Permission;
            fault.write = FALSE;
        elseif AArch64.S2HasPermissionsFault(s2fslwalk, walkstate, walkparams,
            ispriv, acctype, TRUE) then
            // The permission fault _was_ caused by lack of write permissions.
            // However, HW updates, which are atomic writes for stage 1
            // descriptors, permissions fault reflect the original access.
            fault.statuscode = Fault_Permission;
            if !fault.s2fslwalk then
                fault.write = TRUE;
    elseif AArch64.S2HasPermissionsFault(s2fslwalk, walkstate, walkparams,
        ispriv, acctype, iswrite) then
        fault.statuscode = Fault_Permission;

    new_desc = descriptor;
    if walkparams.ha == '1' && AArch64.FaultAllowsSetAccessFlag(fault) then
        // Set descriptor AF bit
        new_desc<10> = '1';

    // If HW update of dirty bit is enabled, the walk state permissions
    // will already reflect a configuration permitting writes.
    // The update of the descriptor occurs only if the descriptor bits in
    // memory do not reflect that and the access instigates a write.
    if (fault.statuscode == Fault_None &&
        walkparams.ha == '1' &&
        walkparams.hd == '1' &&

```

```

        descriptor<51> == '1' && // Descriptor DBM bit
        (IsAtomicRW(acctype) || iswrite) &&
        !(acctype IN {AccType_AT, AccType_ATPAN, AccType_IC, AccType_DC})) then
// Set descriptor S2AP[1] bit permitting stage 2 writes
new_desc<7> = '1';

// Either the access flag was clear or S2AP<1> is clear
if new_desc != descriptor then
    (fault, mem_desc) = AArch64.MemSwapTableDesc(fault, descriptor, new_desc,
                                                    walkparams.ee, descaddress);

if fault.statuscode != Fault_None then
    return (fault, AddressDescriptor UNKNOWN);

ipa_64 = ZeroExtend(ipa.paddress.address, 64);
// Output Address
oa      = Stage0A(walkstate.baseaddress, ipa_64, walkparams.tgx, walkstate.level);

if ((s2fslwalk &&
    walkstate.memattrs.memtype == MemType_Device && walkparams.ptw == '0') ||
    (acctype == AccType_IFETCH &&
    (walkstate.memattrs.memtype == MemType_Device || HCR_EL2.ID == '1')) ||
    (acctype != AccType_IFETCH &&
    walkstate.memattrs.memtype == MemType_Normal && HCR_EL2.CD == '1')) then
// Treat memory attributes as Normal Non-Cacheable
s2_memattrs = NormalNCMemAttr();
s2_memattrs.xs = walkstate.memattrs.xs;
else
    s2_memattrs = walkstate.memattrs;

if !s2fslwalk && acctype == AccType_ATOMICLS64 && s2_memattrs.memtype == MemType_Normal then
    if s2_memattrs.inner.attrs != MemAttr_NC || s2_memattrs.outer.attrs != MemAttr_NC then
        fault.statuscode = Fault_Exclusive;
        return (fault, AddressDescriptor UNKNOWN);

if walkparams.fwb == '0' then
    s2_memattrs = S2CombineS1MemAttrs(ipa.memattrs, s2_memattrs);

pa = CreateAddressDescriptor(ipa.vaddress, oa, s2_memattrs);
return (fault, pa);

```

## Library pseudocode for aarch64/translation/vmsa\_translation/AArch64.TranslateAddress

```

// AArch64.TranslateAddress()
// =====
// Main entry point for translating an address

AddressDescriptor AArch64.TranslateAddress(bits(64) va, AccType acctype,
                                           boolean iswrite, boolean aligned,
                                           integer size)

    result = AArch64.FullTranslate(va, acctype, iswrite, aligned);

    if !IsFault(result) then
        result.fault = AArch64.CheckDebug(va, acctype, iswrite, size);

// Update virtual address for abort functions
result.vaddress = ZeroExtend(va);

return result;

```

## Library pseudocode for aarch64/translation/vmsa\_tentry/AArch64.BlockDescSupported

```
// AArch64.BlockDescSupported()
// =====
// Determine whether a block descriptor is valid for the given granule size
// and level

boolean AArch64.BlockDescSupported(bit ds, TGx tgx, integer level)
    case tgx of
        when TGx\_4KB return level == 2 || level == 1 || (level == 0 && ds == '1');
        when TGx\_16KB return level == 2 || (level == 1 && ds == '1');
        when TGx\_64KB return level == 2 || (level == 1 && AArch64.PAMax() == 52);

    return FALSE;
```

## Library pseudocode for aarch64/translation/vmsa\_tentry/AArch64.BlocknTFaults

```
// AArch64.BlocknTFaults()
// =====
// Identify whether the nT bit in a block descriptor is effectively set
// causing a translation fault

boolean AArch64.BlocknTFaults(bits(64) descriptor)
    if !HaveBlockBBM() then
        return FALSE;

    bbm_level = AArch64.BlockBBMSupportLevel();
    nT_faults = boolean IMPLEMENTATION_DEFINED "BBM level 1 or 2 support nT bit causes Translation Fault";

    return bbm_level IN {1, 2} && descriptor<16> == '1' && nT_faults;
```

## Library pseudocode for aarch64/translation/vmsa\_tentry/AArch64.ContiguousBit

```
// AArch64.ContiguousBit()
// =====
// Get the value of the contiguous bit
// REVISIT AARCH-16801

bit AArch64.ContiguousBit(TGx tgx, integer level, bits(64) descriptor)
    if tgx == TGx\_64KB && level == 1 && !Have52BitVAExt() then
        return '0'; // RES0
    if tgx == TGx\_16KB && level == 1 then
        return '0'; // RES0
    if tgx == TGx\_4KB && level == 0 then
        return '0'; // RES0

    return descriptor<52>;
```

## Library pseudocode for aarch64/translation/vmsa\_tentry/AArch64.ContiguousSizeLog2

```
// AArch64.ContiguousSizeLog2()
// =====
// Given the translation granule and level, determine the number of descriptors
// to the logarithm base 2 that describe a contiguous output space

integer AArch64.ContiguousSizeLog2(TGx tgx, integer level)
    case tgx of
        when TGx\_4KB return 4;
        when TGx\_16KB return if level == 2 then 5 else 7;
        when TGx\_64KB return 5;
```

## Library pseudocode for aarch64/translation/vmsa\_ttentry/AArch64.DecodeDescriptorType

```
// AArch64.DecodeDescriptorType()
// =====
// Determine whether the descriptor is a page, block or table

DescriptorType AArch64.DecodeDescriptorType(bits(64) descriptor, bit ds,
                                           TGx tgx, integer level)
    if descriptor<1:0> == '11' && level == FINAL\_LEVEL then
        return DescriptorType\_Page;
    elseif descriptor<1:0> == '11' then
        return DescriptorType\_Table;
    elseif descriptor<1:0> == '01' then
        if AArch64.BlockDescSupported(ds, tgx, level) then
            return DescriptorType\_Block;
        else
            return DescriptorType\_Invalid;
    else
        return DescriptorType\_Invalid;
```

## Library pseudocode for aarch64/translation/vmsa\_ttentry/AArch64.S1ApplyOutputPerms

```
// AArch64.S1ApplyOutputPerms()
// =====
// Apply output permissions encoded in stage 1 page/block descriptors

Permissions AArch64.S1ApplyOutputPerms(Permissions permissions, bits(64) descriptor,
                                         Regime regime, S1TTWParams walkparams)
    if regime == Regime\_EL10 && EL2Enabled() && walkparams.nv1 == '1' then
        permissions.ap<2:1> = descriptor<7>:'0';
        permissions.pxn     = descriptor<54>;

        return permissions;

    if HasUnprivileged(regime) then
        permissions.ap<2:1> = descriptor<7:6>;
        permissions.uxn     = descriptor<54>;
        permissions.pxn     = descriptor<53>;
    else
        permissions.ap<2:1> = descriptor<7>:'1';
        permissions.xn      = descriptor<54>;

    // Descriptors marked with DBM set have the effective value of AP[2] cleared.
    // This implies no permission faults caused by lack of write permissions are
    // reported, and the Dirty bit can be set.
    if walkparams.ha == '1' && walkparams.hd == '1' && descriptor<51> == '1' then
        permissions.ap<2> = '0';

    return permissions;
```

## Library pseudocode for aarch64/translation/vmsa\_ttentry/AArch64.S1ApplyTablePerms

```
// AArch64.S1ApplyTablePerms()
// =====
// Apply hierarchical permissions encoded in stage 1 table descriptors

Permissions AArch64.S1ApplyTablePerms(Permissions permissions, bits(64) descriptor,
                                       Regime regime, S1TTWParams walkparams)

    if walkparams.hpd == '1' then
        permissions.ap_table = Zeros();
        if HasUnprivileged(regime) then
            permissions.uxn_table = Zeros();
            permissions.pxn_table = Zeros();
        else
            permissions.xn_table = Zeros();

        return permissions;

    if regime == Regime_EL10 && EL2Enabled() && walkparams.nv1 == '1' then
        ap_table = descriptor<62>:'0';
        pxn_table = descriptor<60>;
        permissions.ap_table = permissions.ap_table OR ap_table;
        permissions.pxn_table = permissions.pxn_table OR pxn_table;

        return permissions;

    if HasUnprivileged(regime) then
        ap_table = descriptor<62:61>;
        uxn_table = descriptor<60>;
        pxn_table = descriptor<59>;
        permissions.ap_table = permissions.ap_table OR ap_table;
        permissions.uxn_table = permissions.uxn_table OR uxn_table;
        permissions.pxn_table = permissions.pxn_table OR pxn_table;
    else
        ap_table = descriptor<62>:'0';
        xn_table = descriptor<60>;
        permissions.ap_table = permissions.ap_table OR ap_table;
        permissions.xn_table = permissions.xn_table OR xn_table;

    return permissions;
```

## Library pseudocode for aarch64/translation/vmsa\_ttentry/AArch64.S2ApplyOutputPerms

```
// AArch64.S2ApplyOutputPerms()
// =====
// Apply output permissions encoded in stage 2 page/block descriptors

Permissions AArch64.S2ApplyOutputPerms(bits(64) descriptor, S2TTWParams walkparams)
    Permissions permissions;

    permissions.s2ap = descriptor<7:6>;
    permissions.s2xn = descriptor<54>;

    if HaveExtendedExecuteNeverExt() then
        permissions.s2xnx = descriptor<53>;
    else
        permissions.s2xnx = '0';

    // Descriptors marked with DBM set have the effective value of S2AP[1] set.
    // This implies no permission faults caused by lack of write permissions are
    // reported, and the Dirty bit can be set.
    if walkparams.ha == '1' && walkparams.hd == '1' && descriptor<51> == '1' then
        permissions.s2ap<1> = '1';

    return permissions;
```

## Library pseudocode for aarch64/translation/vmsa\_walk/AArch64.S1InitialTTWState

```
// AArch64.S1InitialTTWState()
// =====
// Set properties of first access to translation tables in stage 1

TTWState AArch64.S1InitialTTWState(S1TTWParams walkparams, bits(64) va,
                                   Regime regime)

    TTWState    walkstate;
    FullAddress tablebase;

    startlevel  = AArch64.S1StartLevel(walkparams);
    ttbr       = AArch64.S1TTBR(regime, va);
    case AArch64.CurrentSecurityState() of
        when SS\_Secure    tablebase.paspace = PAS_Secure;
        when SS\_NonSecure tablebase.paspace = PAS_NonSecure;

    tablebase.address = AArch64.TTBaseAddress(ttbr, walkparams.txsz,
                                             walkparams.ps, walkparams.ds,
                                             walkparams.tgx, startlevel);

    walkstate.baseaddress = tablebase;
    walkstate.level       = startlevel;
    walkstate.istable     = TRUE;
    walkstate.memattrs    = WalkMemAttrs(walkparams.sh, walkparams.irgn,
                                         walkparams.orgn);

    return walkstate;
```

## Library pseudocode for aarch64/translation/vmsa\_walk/AArch64.S1NextWalkStateLast

```
// AArch64.S1NextWalkStateLast()
// =====
// Decode stage 1 page or block descriptor as output to this stage of translation

TTWState AArch64.S1NextWalkStateLast(TTWState currentstate, Regime regime,
                                       S1TTWParams walkparams, bits(64) descriptor)
    TTWState    nextstate;
    FullAddress baseaddress;

    if currentstate.level == FINAL\_LEVEL then
        baseaddress.address = AArch64.PageBase(descriptor, walkparams.ds,
                                                walkparams.tgx);
    else
        baseaddress.address = AArch64.BlockBase(descriptor, walkparams.ds,
                                                walkparams.tgx, currentstate.level);

    if currentstate.baseaddress.paspace == PAS_Secure then
        // Determine PA space of the block from NS bit
        baseaddress.paspace = if descriptor<5> == '0' then PAS_Secure else PAS_NonSecure;
    else
        baseaddress.paspace = PAS_NonSecure;

    nextstate.istable      = FALSE;
    nextstate.level       = currentstate.level;
    nextstate.baseaddress = baseaddress;

    attrindx = descriptor<4:2>;
    sh = if walkparams.ds == '1' then walkparams.sh else descriptor<9:8>;
    attr = MAIRAttr(UInt(attrindx), walkparams.mair);
    slaarch64 = TRUE;

    nextstate.memattrs     = S1DecodeMemAttrs(attr, sh, slaarch64);
    nextstate.permissions = AArch64.S1ApplyOutputPerms(currentstate.permissions,
                                                        descriptor, regime, walkparams);
    nextstate.contiguous  = AArch64.ContiguousBit(walkparams.tgx, currentstate.level,
                                                  descriptor);
    nextstate.guardedpage = descriptor<50>;

    return nextstate;
```

## Library pseudocode for aarch64/translation/vmsa\_walk/AArch64.S1NextWalkStateTable

```
// AArch64.S1NextWalkStateTable()
// =====
// Decode stage 1 table descriptor to transition to the next level

TTWState AArch64.S1NextWalkStateTable(TTWState currentstate, Regime regime,
                                       S1TTWParams walkparams, bits(64) descriptor)

    TTWState    nextstate;
    FullAddress tablebase;

    tablebase.address = AArch64.NextTableBase(descriptor, walkparams.ds,
                                             walkparams.tgx);
    if currentstate.baseaddress.paspace == PAS_Secure then
        // Determine PA space of the next table from NSTable bit
        tablebase.paspace = if descriptor<63> == '0' then PAS_Secure else PAS_NonSecure;
    else
        // Otherwise bit 63 is RES0 and there is no NSTable bit
        tablebase.paspace = currentstate.baseaddress.paspace;

    nextstate.istable      = TRUE;
    nextstate.level       = currentstate.level + 1;
    nextstate.baseaddress = tablebase;
    nextstate.memattrs     = currentstate.memattrs;
    nextstate.permissions = AArch64.S1ApplyTablePerms(currentstate.permissions,
                                                    descriptor, regime,
                                                    walkparams);

    return nextstate;
```





```

// AArch64.S1Walk()
// =====
// Traverse stage 1 translation tables obtaining the final descriptor
// as well as the address leading to that descriptor

(FaultRecord, AddressDescriptor, TTWState, bits(64)) AArch64.S1Walk(
    FaultRecord fault, S1TTWParams walkparams, bits(64) va, Regime regime,
    AccType acctype, boolean iswrite)
if HasUnprivileged(regime) && AArch64.S1EPD(regime, va) == '1' then
    fault.statuscode = Fault_Translation;
    fault.level      = 0;
    return (fault, AddressDescriptor UNKNOWN, TTWState UNKNOWN,
        bits(64) UNKNOWN);

if PSTATE.EL == EL0 && walkparams.nfd == '1' then
    if acctype == AccType_NONFAULT then
        fault.statuscode = Fault_Translation;
        fault.level      = 0;
        return (fault, AddressDescriptor UNKNOWN, TTWState UNKNOWN,
            bits(64) UNKNOWN);

    if AArch64.S1InvalidTxSZ(walkparams) then
        fault.statuscode = Fault_Translation;
        fault.level      = 0;
        return (fault, AddressDescriptor UNKNOWN, TTWState UNKNOWN,
            bits(64) UNKNOWN);

walkstate = AArch64.S1InitialTTWState(walkparams, va, regime);

// Detect Address Size Fault by TTB
if AArch64.OAOutOfRange(walkstate, walkparams.ps, walkparams.tgx) then
    fault.statuscode = Fault_AddressSize;
    fault.level      = 0;
    return (fault, AddressDescriptor UNKNOWN, TTWState UNKNOWN,
        bits(64) UNKNOWN);

bits(64) descriptor;
repeat
    fault.level = walkstate.level;

    FullAddress descaddress = AArch64.TTEntryAddress(walkstate.level, walkparams.tgx,
        walkparams.txsz, va,
        walkstate.baseaddress);

    if !AArch64.S1DCacheEnabled(regime) then
        walkmemattrs = NormalNCMemAttr();
        walkmemattrs.xs = walkstate.memattrs.xs;
    else
        walkmemattrs = walkstate.memattrs;

    // If the target memory for translation table walks is Normal memory
    // inner Non-Cacheable outer Non-Cacheable then it is forced to Outer Shareable
    // Note: this behaviour is overridden for addresses subject to stage 2.
    if (walkmemattrs.inner.attrs == MemAttr_NC &&
        walkmemattrs.outer.attrs == MemAttr_NC) then
        walkmemattrs.shareability = Shareability_OSH;

walkaddress = CreateAddressDescriptor(va, descaddress, walkmemattrs);

if regime == Regime_EL10 && EL2Enabled() then
    // Shareability of target memory subject to stage 2 translation
    // is maintained as input to stage 2
    if HCR_EL2.VM == '1' then
        walkaddress.memattrs.shareability = walkstate.memattrs.shareability;

    slaarch64 = TRUE;
    s2fslwalk = TRUE;
    aligned    = TRUE;
    iswrite    = FALSE;
    (s2fault, s2walkaddress) = AArch64.S2Translate(fault, walkaddress,

```

```

        slaarch64, s2fslwalk, AccType\_TTW,
        aligned, iswrite);

    if s2fault.statuscode != Fault\_None then
        return (s2fault, AddressDescriptor UNKNOWN, TTWState UNKNOWN,
            bits(64) UNKNOWN);

    (fault, descriptor) = FetchDescriptor(walkparams.ee, s2walkaddress, fault);
else
    (fault, descriptor) = FetchDescriptor(walkparams.ee, walkaddress, fault);

if fault.statuscode != Fault\_None then
    return (fault, AddressDescriptor UNKNOWN, TTWState UNKNOWN,
        bits(64) UNKNOWN);

desctype = AArch64.DecodeDescriptorType(descriptor, walkparams.ds,
    walkparams.tgx, walkstate.level);

case desctype of
    when DescriptorType\_Table
        walkstate = AArch64.S1NextWalkStateTable(walkstate, regime,
            walkparams, descriptor);

        // Detect Address Size Fault by table descriptor
        if AArch64.OAOutOfRange(walkstate, walkparams.ps, walkparams.tgx) then
            fault.statuscode = Fault\_AddressSize;
            return (fault, AddressDescriptor UNKNOWN, TTWState UNKNOWN,
                bits(64) UNKNOWN);

    when DescriptorType\_Page, DescriptorType\_Block
        walkstate = AArch64.S1NextWalkStateLast(walkstate, regime,
            walkparams, descriptor);

    when DescriptorType\_Invalid
        fault.statuscode = Fault\_Translation;
        return (fault, AddressDescriptor UNKNOWN, TTWState UNKNOWN,
            bits(64) UNKNOWN);

    otherwise
        Unreachable();

until desctype IN {DescriptorType\_Page, DescriptorType\_Block};

if (walkstate.contiguous == '1' &&
    AArch64.ContiguousBitFaults(walkparams.txsz, walkparams.tgx,
        walkstate.level)) then
    fault.statuscode = Fault\_Translation;
elsif desctype == DescriptorType\_Block && AArch64.BlocknTFaults(descriptor) then
    fault.statuscode = Fault\_Translation;
// Detect Address Size Fault by final output
elsif AArch64.OAOutOfRange(walkstate, walkparams.ps, walkparams.tgx) then
    fault.statuscode = Fault\_AddressSize;
// Check descriptor AF bit
elsif descriptor<10> == '0' && walkparams.ha == '0' then
    fault.statuscode = Fault\_AccessFlag;

if fault.statuscode != Fault\_None then
    return (fault, AddressDescriptor UNKNOWN, TTWState UNKNOWN,
        bits(64) UNKNOWN);
else
    return (fault, walkaddress, walkstate, descriptor);

```

## Library pseudocode for aarch64/translation/vmsa\_walk/AArch64.S2InitialTTWState

```
// AArch64.S2InitialTTWState()
// =====
// Set properties of first access to translation tables in stage 2

TTWState AArch64.S2InitialTTWState(S2TTWParams walkparams)
    TTWState    walkstate;
    FullAddress tablebase;

    ttbr        = VTTBR_EL2;
    startlevel   = AArch64.S2StartLevel(walkparams);
    tablebase.paspace = PAS_NonSecure;
    tablebase.address = AArch64.TTBaseAddress(ttbr, walkparams.txsz,
                                              walkparams.ps, walkparams.ds,
                                              walkparams.tgx, startlevel);

    walkstate.baseaddress = tablebase;
    walkstate.level       = startlevel;
    walkstate.istable     = TRUE;
    walkstate.memattrs    = WalkMemAttrs(walkparams.sh, walkparams.irgn,
                                         walkparams.orgn);

    return walkstate;
```

## Library pseudocode for aarch64/translation/vmsa\_walk/AArch64.S2NextWalkStateLast

```
// AArch64.S2NextWalkStateLast()
// =====
// Decode stage 2 page or block descriptor as output to this stage of translation

TTWState AArch64.S2NextWalkStateLast(TTWState currentstate, S2TTWParams walkparams,
                                      AddressDescriptor ipa, bits(64) descriptor)

    TTWState    nextstate;
    FullAddress baseaddress;

    if AArch64.CurrentSecurityState() == SS_Secure then
        baseaddress.paspace = AArch64.SS2OutputPASpace(walkparams,
                                                         ipa.paddress.paspace);
    else
        baseaddress.paspace = PAS_NonSecure;

    if currentstate.level == FINAL_LEVEL then
        baseaddress.address = AArch64.PageBase(descriptor, walkparams.ds,
                                                walkparams.tgx);
    else
        baseaddress.address = AArch64.BlockBase(descriptor, walkparams.ds,
                                                walkparams.tgx, currentstate.level);

    nextstate.istable    = FALSE;
    nextstate.level      = currentstate.level;
    nextstate.baseaddress = baseaddress;
    nextstate.permissions = AArch64.S2ApplyOutputPerms(descriptor, walkparams);

    s2_attr = descriptor<5:2>;
    s2_sh   = if walkparams.ds == '1' then walkparams.sh else descriptor<9:8>;
    s2_fnxs = descriptor<11>;
    if walkparams.fwb == '1' then
        nextstate.memattrs = AArch64.S2ApplyFWBMemAttrs(ipa.memattrs, s2_attr, s2_sh);
        if s2_attr<1:0> == '10' then // Force writeback
            nextstate.memattrs.xs = '0';
        else
            nextstate.memattrs.xs = if s2_fnxs == '1' then '0' else ipa.memattrs.xs;
    else
        nextstate.memattrs = S2DecodeMemAttrs(s2_attr, s2_sh);
        nextstate.memattrs.xs = if s2_fnxs == '1' then '0' else ipa.memattrs.xs;
    nextstate.contiguous = AArch64.ContiguousBit(walkparams.tgx, currentstate.level,
                                                descriptor);

    return nextstate;
```

## Library pseudocode for aarch64/translation/vmsa\_walk/AArch64.S2NextWalkStateTable

```
// AArch64.S2NextWalkStateTable()
// =====
// Decode stage 2 table descriptor to transition to the next level

TTWState AArch64.S2NextWalkStateTable(TTWState currentstate,
                                      S2TTWParams walkparams,
                                      bits(64) descriptor)

    TTWState    nextstate;
    FullAddress tablebase;

    tablebase.address = AArch64.NextTableBase(descriptor, walkparams.ds,
                                                walkparams.tgx);
    tablebase.paspace = currentstate.baseaddress.paspace;

    nextstate.istable    = TRUE;
    nextstate.level      = currentstate.level + 1;
    nextstate.baseaddress = tablebase;
    nextstate.memattrs    = currentstate.memattrs;

    return nextstate;
```



```

// AArch64.S2Walk()
// =====
// Traverse stage 2 translation tables obtaining the final descriptor
// as well as the address leading to that descriptor

(FaultRecord, AddressDescriptor, TTWState, bits(64)) AArch64.S2Walk(
    FaultRecord fault, AddressDescriptor ipa, S2TTWParams walkparams,
    AccType acctype, boolean iswrite, boolean slaarch64)
if (AArch64.S2InvalidTxSZ(walkparams, slaarch64) ||
    AArch64.S2InvalidSL(walkparams) ||
    AArch64.S2InconsistentSL(walkparams)) then
    fault.statuscode = Fault\_Translation;
    fault.level = 0;
    return (fault, AddressDescriptor UNKNOWN, TTWState UNKNOWN,
        bits(64) UNKNOWN);

if AArch64.CurrentSecurityState() == SS\_Secure then
    walkstate = AArch64.S2InitialTTWState(walkparams, ipa.paddress.paspace);
else
    walkstate = AArch64.S2InitialTTWState(walkparams);

// Detect Address Size Fault by TTB
if AArch64.OAOutOfRange(walkstate, walkparams.ps, walkparams.tgx) then
    fault.statuscode = Fault\_AddressSize;
    fault.level = 0;
    return (fault, AddressDescriptor UNKNOWN, TTWState UNKNOWN,
        bits(64) UNKNOWN);

bits(64) descriptor;
repeat
    fault.level = walkstate.level;

    FullAddress descaddress;
    if walkstate.level == AArch64.S2StartLevel(walkparams) then
        // Initial lookup might index into concatenated tables
        descaddress = AArch64.S2SLTTEEntryAddress(walkparams, ipa.paddress.address,
            walkstate.baseaddress);
    else
        ipa_64 = ZeroExtend(ipa.paddress.address, 64);
        descaddress = AArch64.TTEEntryAddress(walkstate.level, walkparams.tgx,
            walkparams.txsz, ipa_64,
            walkstate.baseaddress);

    if HCR_EL2.CD == '1' then
        walkmemattrs = NormalNCMemAttr();
        walkmemattrs.xs = walkstate.memattrs.xs;
    else
        walkmemattrs = walkstate.memattrs;

    // If the target memory for translation table walks is Normal memory
    // inner Non-Cacheable outer Non-Cacheable then it is forced to Outer Shareable
    if (walkmemattrs.inner.attrs == MemAttr\_NC &&
        walkmemattrs.outer.attrs == MemAttr\_NC) then
        walkmemattrs.shareability = Shareability\_OSH;

    // VA parameter is for the Abort() call on the other side of _Mem
    walkaddress = CreateAddressDescriptor(ipa.vaddress, descaddress, walkmemattrs);

    (fault, descriptor) = FetchDescriptor(walkparams.ee, walkaddress, fault);

    if fault.statuscode != Fault\_None then
        return (fault, AddressDescriptor UNKNOWN, TTWState UNKNOWN,
            bits(64) UNKNOWN);

    desctype = AArch64.DecodeDescriptorType(descriptor, walkparams.ds,
        walkparams.tgx, walkstate.level);

    case desctype of
        when DescriptorType\_Table
            walkstate = AArch64.S2NextWalkStateTable(walkstate, walkparams,

```

```

descriptor);

// Detect Address Size Fault by table descriptor
if AArch64.OAOutOfRange(walkstate, walkparams.ps, walkparams.tgx) then
    fault.statuscode = Fault\_AddressSize;
    return (fault, AddressDescriptor UNKNOWN, TTWState UNKNOWN,
            bits(64) UNKNOWN);

when DescriptorType\_Page, DescriptorType\_Block
    walkstate = AArch64.S2NextWalkStateLast(walkstate, walkparams,
                                              ipa, descriptor);

when DescriptorType\_Invalid
    fault.statuscode = Fault\_Translation;
    return (fault, AddressDescriptor UNKNOWN, TTWState UNKNOWN,
            bits(64) UNKNOWN);

otherwise
    Unreachable\(\);

until desctype IN {DescriptorType\_Page, DescriptorType\_Block};

if (walkstate.contiguous == '1' &&
    AArch64.ContiguousBitFaults(walkparams.txsz, walkparams.tgx,
                                walkstate.level)) then
    fault.statuscode = Fault\_Translation;
elseif desctype == DescriptorType\_Block && AArch64.BlocknTFaults(descriptor) then
    fault.statuscode = Fault\_Translation;
// Detect Address Size Fault by final output
elseif AArch64.OAOutOfRange(walkstate, walkparams.ps, walkparams.tgx) then
    fault.statuscode = Fault\_AddressSize;
// Check descriptor AF bit
elseif descriptor<10> == '0' && walkparams.ha == '0' then
    fault.statuscode = Fault\_AccessFlag;

if fault.statuscode != Fault\_None then
    return (fault, AddressDescriptor UNKNOWN, TTWState UNKNOWN, bits(64) UNKNOWN);
else
    return (fault, walkaddress, walkstate, descriptor);

```



## Library pseudocode for aarch64/translation/vmsa\_walk/AArch64.SS2InitialTTWState

```
// AArch64.SS2InitialTTWState()
// =====
// Set properties of first access to translation tables in Secure stage 2

TTWState AArch64.SS2InitialTTWState(S2TTWParams walkparams, PASpace ipaspace)
    TTWState    walkstate;
    FullAddress tablebase;

    if ipaspace == PAS_Secure then
        ttbr = VSTTBR_EL2;
    else
        ttbr = VTTBR_EL2;

    if ipaspace == PAS_Secure then
        if walkparams.sw == '0' then
            tablebase.paspace = PAS_Secure;
        else
            tablebase.paspace = PAS_NonSecure;
    else
        if walkparams.nsw == '0' then
            tablebase.paspace = PAS_Secure;
        else
            tablebase.paspace = PAS_NonSecure;

    startlevel      = AArch64.S2StartLevel(walkparams);
    tablebase.address = AArch64.TTBaseAddress(ttbr, walkparams.txsz,
                                              walkparams.ps, walkparams.ds,
                                              walkparams.tgx, startlevel);

    walkstate.baseaddress = tablebase;
    walkstate.level       = startlevel;
    walkstate.istable     = TRUE;
    walkstate.memattrs    = WalkMemAttrs(walkparams.sh, walkparams.irgn,
                                          walkparams.orgn);

    return walkstate;
```

## Library pseudocode for aarch64/translation/vmsa\_walk/AArch64.SS2OutputPASpace

```
// AArch64.SS2OutputPASpace()
// =====
// Assign PA Space to output of Secure stage 2 translation

PASpace AArch64.SS2OutputPASpace(S2TTWParams walkparams, PASpace ipaspace)
    if ipaspace == PAS_Secure then
        if walkparams.<sw,sa> == '00' then
            return PAS_Secure;
        else
            return PAS_NonSecure;
    else
        if walkparams.<sw,sa,nsw,nsa> == '0000' then
            return PAS_Secure;
        else
            return PAS_NonSecure;
```

## Library pseudocode for aarch64/translation/vmsa\_walkparams/AArch64.BBMSupportLevel

```
// AArch64.BBMSupportLevel()
// =====
// Returns the level of FEAT_BBM supported

integer AArch64.BlockBBMSupportLevel()
    if !HaveBlockBBM() then
        return integer UNKNOWN;
    else
        return integer IMPLEMENTATION_DEFINED "Block BBM support level";
```

## Library pseudocode for aarch64/translation/vmsa\_walkparams/AArch64.CurrentSecurityState

```
// AArch64.CurrentSecurityState()
// =====
// Return security state of current EL

SecurityState AArch64.CurrentSecurityState()
    return SecurityStateAtEL(PSTATE.EL);
```

## Library pseudocode for aarch64/translation/vmsa\_walkparams/AArch64.DecodeTG0

```
// AArch64.DecodeTG0()
// =====
// Decode granule size configuration bits TG0

TGx AArch64.DecodeTG0(bits(2) tg0)
    if tg0 == '11' then
        tg0 = bits(2) IMPLEMENTATION_DEFINED "Reserved TG0 encoding granule size";

    case tg0 of
        when '00'    return TGx\_4KB;
        when '01'    return TGx\_64KB;
        when '10'    return TGx\_16KB;
```

## Library pseudocode for aarch64/translation/vmsa\_walkparams/AArch64.DecodeTG1

```
// AArch64.DecodeTG1()
// =====
// Decode granule size configuration bits TG1

TGx AArch64.DecodeTG1(bits(2) tg1)
    if tg1 == '00' then
        tg1 = bits(2) IMPLEMENTATION_DEFINED "Reserved TG1 encoding granule size";

    case tg1 of
        when '10'    return TGx\_4KB;
        when '11'    return TGx\_64KB;
        when '01'    return TGx\_16KB;
```

## Library pseudocode for aarch64/translation/vmsa\_walkparams/AArch64.GetS1TTWParams

```
// AArch64.GetS1TTWParams()
// =====
// Returns stage 1 translation table walk parameters from respective controlling
// system registers.

S1TTWParams AArch64.GetS1TTWParams(Regime regime, bits(64) va)
    S1TTWParams walkparams;

    varange = AArch64.GetVARange(va);

    case regime of
        when Regime\_EL3    walkparams = AArch64.S1TTWParamsEL3();
        when Regime\_EL2    walkparams = AArch64.S1TTWParamsEL2();
        when Regime\_EL20    walkparams = AArch64.S1TTWParamsEL20(varange);
        when Regime\_EL10    walkparams = AArch64.S1TTWParamsEL10(varange);

    maxtxsz = AArch64.MaxTxSZ(walkparams.tgx);
    mintxsz = AArch64.S1MinTxSZ(walkparams.ds, walkparams.tgx);
    if UInt(walkparams.txsz) > maxtxsz then
        if !(boolean IMPLEMENTATION_DEFINED "Fault on TxSZ value above maximum") then
            walkparams.txsz = maxtxsz<5:0>;
    elsif !HaveS2BitVAExt() && UInt(walkparams.txsz) < mintxsz then
        if !(boolean IMPLEMENTATION_DEFINED "Fault on TxSZ value below minimum") then
            walkparams.txsz = mintxsz<5:0>;

    return walkparams;
```

## Library pseudocode for aarch64/translation/vmsa\_walkparams/AArch64.GetS2TTWParams

```
// AArch64.GetS2TTWParams()
// =====
// Gather walk parameters for stage 2 translation

S2TTWParams AArch64.GetS2TTWParams(PASpace ipaspace, boolean slaarch64)
    S2TTWParams walkparams;

    ss = AArch64.CurrentSecurityState();
    if ss == SS_NonSecure then
        walkparams = AArch64.NSS2TTWParams(slaarch64);
    elseif HaveSecureEL2Ext() && ss == SS_Secure then
        walkparams = AArch64.SS2TTWParams(ipaspace, slaarch64);
    else
        Unreachable();

    maxtxsz = AArch64.MaxTxSZ(walkparams.tgx);
    mintxsz = AArch64.S2MinTxSZ(walkparams.ds, walkparams.tgx, slaarch64);
    if UInt(walkparams.txsz) > maxtxsz then
        if !(boolean IMPLEMENTATION_DEFINED "Fault on TxSZ value above maximum") then
            walkparams.txsz = maxtxsz<5:0>;
    elseif !Have52BitPAExt() && UInt(walkparams.txsz) < mintxsz then
        if !(boolean IMPLEMENTATION_DEFINED "Fault on TxSZ value below minimum") then
            walkparams.txsz = mintxsz<5:0>;

    return walkparams;
```

## Library pseudocode for aarch64/translation/vmsa\_walkparams/AArch64.GetVARange

```
// AArch64.GetVARange()
// =====
// Determines if the VA that is to be translated lies in LOWER or UPPER address range.

VARange AArch64.GetVARange(bits(64) va)
    if va<55> == '0' then
        return VARange_LOWER;
    else
        return VARange_UPPER;
```

## Library pseudocode for aarch64/translation/vmsa\_walkparams/AArch64.MaxTxSZ

```
// AArch64.MaxTxSZ()
// =====
// Retrieve the maximum value of TxSZ indicating minimum input address size for both
// stages of translation

integer AArch64.MaxTxSZ(TGx tgx)
    if HaveSmallTranslationTableExt() && !UsingAArch32() then
        case tgx of
            when TGx_4KB    return 48;
            when TGx_16KB   return 48;
            when TGx_64KB   return 47;
    return 39;
```

## Library pseudocode for aarch64/translation/vmsa\_walkparams/AArch64.NSS2TTWParams

```
// AArch64.NSS2TTWParams()
// =====
// Gather walk parameters specific for Non-secure stage 2 translation

S2TTWParams AArch64.NSS2TTWParams(boolean slaarch64)
    S2TTWParams walkparams;

    walkparams.vm = HCR_EL2.VM OR HCR_EL2.DC;
    walkparams.tgx = AArch64.DecodeTG0(VTCR_EL2.TG0);
    walkparams.txsz = VTCR_EL2.T0SZ;
    walkparams.sl0 = VTCR_EL2.SL0;
    walkparams.ps = VTCR_EL2.PS;
    walkparams.irgn = VTCR_EL2.IRGN0;
    walkparams.orgn = VTCR_EL2.ORGNO;
    walkparams.sh = VTCR_EL2.SH0;
    walkparams.ee = SCTLR_EL2.EE;

    walkparams.ptw = if HCR_EL2.TGE == '0' then HCR_EL2.PTW else '0';
    walkparams.fwb = if HaveStage2MemAttrControl() then HCR_EL2.FWB else '0';
    walkparams.ha = if HaveAccessFlagUpdateExt() then VTCR_EL2.HA else '0';
    walkparams.hd = if HaveDirtyBitModifierExt() then VTCR_EL2.HD else '0';
    if walkparams.tgx IN {TGx_4KB, TGx_16KB} && Have52BitIPAAAndPASpaceExt() then
        walkparams.ds = VTCR_EL2.DS;
    else
        walkparams.ds = '0';
    if walkparams.tgx == TGx_4KB && Have52BitIPAAAndPASpaceExt() then
        walkparams.sl2 = VTCR_EL2.SL2 AND VTCR_EL2.DS;
    else
        walkparams.sl2 = '0';

    return walkparams;
```

## Library pseudocode for aarch64/translation/vmsa\_walkparams/AArch64.PAMax

```
// AArch64.PAMax()
// =====
// Returns the IMPLEMENTATION_DEFINED maximum number of bits capable of representing
// physical address for this processor

integer AArch64.PAMax()
    return integer IMPLEMENTATION_DEFINED "Maximum Physical Address Size";
```

## Library pseudocode for aarch64/translation/vmsa\_walkparams/AArch64.S1DCacheEnabled

```
// AArch64.S1DCacheEnabled()
// =====
// Determine cacheability of stage 1 data accesses

boolean AArch64.S1DCacheEnabled(Regime regime)
    case regime of
        when Regime_EL3 return SCTLR_EL3.C == '1';
        when Regime_EL2 return SCTLR_EL2.C == '1';
        when Regime_EL20 return SCTLR_EL2.C == '1';
        when Regime_EL10 return SCTLR_EL1.C == '1';
```

### Library pseudocode for aarch64/translation/vmsa\_walkparams/AArch64.S1EPD

```
// AArch64.S1EPD()
// =====
// Determine whether stage 1 translation table walk is allowed for the VA range

bit AArch64.S1EPD(Regime regime, bits(64) va)
    assert HasUnprivileged(regime);
    varange = AArch64.GetVARange(va);

    case regime of
        when Regime_EL20 return if varange == VARange_LOWER then TCR_EL2.EPD0 else TCR_EL2.EPD1;
        when Regime_EL10 return if varange == VARange_LOWER then TCR_EL1.EPD0 else TCR_EL1.EPD1;
```

### Library pseudocode for aarch64/translation/vmsa\_walkparams/AArch64.S1Enabled

```
// AArch64.S1Enabled()
// =====
// Determine if stage 1 for the acting translation regime is enabled

boolean AArch64.S1Enabled(Regime regime)
    case regime of
        when Regime_EL3 return SCTLR_EL3.M == '1';
        when Regime_EL2 return SCTLR_EL2.M == '1';
        when Regime_EL20 return SCTLR_EL2.M == '1';
        when Regime_EL10 return (!EL2Enabled() || HCR_EL2.<DC,TGE> == '00') && SCTLR_EL1.M == '1';
```

### Library pseudocode for aarch64/translation/vmsa\_walkparams/AArch64.S1ICacheEnabled

```
// AArch64.S1ICacheEnabled()
// =====
// Determine cacheability of stage 1 instruction fetches

boolean AArch64.S1ICacheEnabled(Regime regime)
    case regime of
        when Regime_EL3 return SCTLR_EL3.I == '1';
        when Regime_EL2 return SCTLR_EL2.I == '1';
        when Regime_EL20 return SCTLR_EL2.I == '1';
        when Regime_EL10 return SCTLR_EL1.I == '1';
```

### Library pseudocode for aarch64/translation/vmsa\_walkparams/AArch64.S1MinTxSZ

```
// AArch64.S1MinTxSZ()
// =====
// Retrieve the minimum value of TxSZ indicating maximum input address size for stage 1

integer AArch64.S1MinTxSZ(bit ds, TGx tgx)
    if (Have52BitVAExt() && tgx == TGx_64KB) || ds == '1' then
        return 12;

    return 16;
```

### Library pseudocode for aarch64/translation/vmsa\_walkparams/AArch64.S1TTBR

```
// AArch64.S1TTBR()
// =====
// Identify stage 1 table base register for the acting translation regime

bits(64) AArch64.S1TTBR(Regime regime, bits(64) va)
    varange = AArch64.GetVARange(va);

    case regime of
        when Regime_EL3 return TTBR0_EL3;
        when Regime_EL2 return TTBR0_EL2;
        when Regime_EL20 return if varange == VARange_LOWER then TTBR0_EL2 else TTBR1_EL2;
        when Regime_EL10 return if varange == VARange_LOWER then TTBR0_EL1 else TTBR1_EL1;
```

## Library pseudocode for aarch64/translation/vmsa\_walkparams/AArch64.S1TTWParamsEL10

```
// AArch64.S1TTWParamsEL10()
// =====
// Gather stage 1 translation table walk parameters for EL1&0 regime
// (with EL2 enabled or disabled)

S1TTWParams AArch64.S1TTWParamsEL10(VARange varange)
    S1TTWParams walkparams;

    if varange == VARange_LOWER then
        walkparams.tgx = AArch64.DecodeTG0(TCR_EL1.TG0);
        walkparams.txsz = TCR_EL1.T0SZ;
        walkparams.irgn = TCR_EL1.IRGN0;
        walkparams.orgn = TCR_EL1.ORGNO;
        walkparams.sh = TCR_EL1.SH0;
        walkparams.tbi = TCR_EL1.TBI0;

        walkparams.nfd = if HaveSVE() then TCR_EL1.NFD0 else '0';
        walkparams.tbid = if HavePACExt() then TCR_EL1.TBID0 else '0';
        walkparams.e0pd = if HaveE0PDEExt() then TCR_EL1.E0PD0 else '0';
        walkparams.hpd = if AArch64.HaveHPDEExt() then TCR_EL1.HPD0 else '0';
    else
        walkparams.tgx = AArch64.DecodeTG1(TCR_EL1.TG1);
        walkparams.txsz = TCR_EL1.T1SZ;
        walkparams.irgn = TCR_EL1.IRGN1;
        walkparams.orgn = TCR_EL1.ORGNO;
        walkparams.sh = TCR_EL1.SH1;
        walkparams.tbi = TCR_EL1.TBI1;

        walkparams.nfd = if HaveSVE() then TCR_EL1.NFD1 else '0';
        walkparams.tbid = if HavePACExt() then TCR_EL1.TBID1 else '0';
        walkparams.e0pd = if HaveE0PDEExt() then TCR_EL1.E0PD1 else '0';
        walkparams.hpd = if AArch64.HaveHPDEExt() then TCR_EL1.HPD1 else '0';

    walkparams.mair = MAIR_EL1;
    walkparams.wxn = SCTLR_EL1.WXN;
    walkparams.ps = TCR_EL1.IPS;
    walkparams.ee = SCTLR_EL1.EE;
    walkparams.sif = SCR_EL3.SIF;

    if EL2Enabled() then
        walkparams.dc = HCR_EL2.DC;
        walkparams.dct = if HaveMTE2Ext() then HCR_EL2.DCT else '0';

    if HaveTrapLoadStoreMultipleDeviceExt() then
        walkparams.ntlsmid = SCTLR_EL1.nTlSMID;
    else
        walkparams.ntlsmid = '1';

    if EL2Enabled() then
        if HCR_EL2.<NV,NV1> == '01' then
            case Constraint_NVNV1_Unpredictable(Unpredictable_NVNV1) of
                when Constraint_NVNV1_00 walkparams.nv1 = '0';
                when Constraint_NVNV1_01 walkparams.nv1 = '1';
                when Constraint_NVNV1_11 walkparams.nv1 = '1';
            else
                walkparams.nv1 = HCR_EL2.NV1;
        else
            walkparams.nv1 = '0';

    walkparams.epan = if HavePAN3Ext() then SCTLR_EL1.EPAN else '0';
    walkparams.ha = if HaveAccessFlagUpdateExt() then TCR_EL1.HA else '0';
    walkparams.hd = if HaveDirtyBitModifierExt() then TCR_EL1.HD else '0';
    if walkparams.tgx IN {TGx_4KB, TGx_16KB} && Have52BitIPAAAndPASpaceExt() then
        walkparams.ds = TCR_EL1.DS;
    else
        walkparams.ds = '0';

    return walkparams;
```

## Library pseudocode for aarch64/translation/vmsa\_walkparams/AArch64.S1TTWParamsEL2

```
// AArch64.S1TTWParamsEL2()
// =====
// Gather stage 1 translation table walk parameters for EL2 regime

S1TTWParams AArch64.S1TTWParamsEL2()
    S1TTWParams walkparams;

    walkparams.tgx = AArch64.DecodeTG0(TCR_EL2.TG0);
    walkparams.txsz = TCR_EL2.T0SZ;
    walkparams.ps = TCR_EL2.PS;
    walkparams.irgn = TCR_EL2.IRGN0;
    walkparams.orgn = TCR_EL2.ORGNO;
    walkparams.sh = TCR_EL2.SH0;
    walkparams.tbi = TCR_EL2.TBI;
    walkparams.mair = MAIR_EL2;
    walkparams.wxn = SCTLR_EL2.WXN;
    walkparams.ee = SCTLR_EL2.EE;
    walkparams.sif = SCR_EL3.SIF;

    walkparams.tbid = if HavePACExt() then TCR_EL2.TBID else '0';
    walkparams.hpd = if AArch64.HaveHPDExt() then TCR_EL2.HPD else '0';
    walkparams.ha = if HaveAccessFlagUpdateExt() then TCR_EL2.HA else '0';
    walkparams.hd = if HaveDirtyBitModifierExt() then TCR_EL2.HD else '0';
    if walkparams.tgx IN {TGx_4KB, TGx_16KB} && Have52BitIPAAAndPASpaceExt() then
        walkparams.ds = TCR_EL2.DS;
    else
        walkparams.ds = '0';

    return walkparams;
```

## Library pseudocode for aarch64/translation/vmsa\_walkparams/AArch64.S1TTWParamsEL20

```
// AArch64.S1TTWParamsEL20()
// =====
// Gather stage 1 translation table walk parameters for EL2&0 regime

S1TTWParams AArch64.S1TTWParamsEL20(VARange varange)
    S1TTWParams walkparams;

    if varange == VARange_LOWER then
        walkparams.tgx = AArch64.DecodeTG0(TCR_EL2.TG0);
        walkparams.txsz = TCR_EL2.T0SZ;
        walkparams.irgn = TCR_EL2.IRGN0;
        walkparams.orgn = TCR_EL2.ORGNO;
        walkparams.sh = TCR_EL2.SH0;
        walkparams.tbi = TCR_EL2.TBI0;

        walkparams.nfd = if HaveSVE() then TCR_EL2.NFD0 else '0';
        walkparams.tbid = if HavePACExt() then TCR_EL2.TBID0 else '0';
        walkparams.e0pd = if HaveE0PDEExt() then TCR_EL2.E0PD0 else '0';
        walkparams.hpd = if AArch64.HaveHPDEExt() then TCR_EL2.HPD0 else '0';
    else
        walkparams.tgx = AArch64.DecodeTG1(TCR_EL2.TG1);
        walkparams.txsz = TCR_EL2.T1SZ;
        walkparams.irgn = TCR_EL2.IRGN1;
        walkparams.orgn = TCR_EL2.ORG1;
        walkparams.sh = TCR_EL2.SH1;
        walkparams.tbi = TCR_EL2.TBI1;

        walkparams.nfd = if HaveSVE() then TCR_EL2.NFD1 else '0';
        walkparams.tbid = if HavePACExt() then TCR_EL2.TBID1 else '0';
        walkparams.e0pd = if HaveE0PDEExt() then TCR_EL2.E0PD1 else '0';
        walkparams.hpd = if AArch64.HaveHPDEExt() then TCR_EL2.HPD1 else '0';

    walkparams.mair = MAIR_EL2;
    walkparams.wxn = SCTL_EL2.WXN;
    walkparams.ps = TCR_EL2.IPS;
    walkparams.ee = SCTL_EL2.EE;
    walkparams.sif = SCR_EL3.SIF;

    if HaveTrapLoadStoreMultipleDeviceExt() then
        walkparams.ntlsmid = SCTL_EL2.nTlSMID;
    else
        walkparams.ntlsmid = '1';

    walkparams.epan = if HavePAN3Ext() then SCTL_EL2.EPAN else '0';
    walkparams.ha = if HaveAccessFlagUpdateExt() then TCR_EL2.HA else '0';
    walkparams.hd = if HaveDirtyBitModifierExt() then TCR_EL2.HD else '0';
    if walkparams.tgx IN {TGx_4KB, TGx_16KB} && Have52BitIPAAAndPASpaceExt() then
        walkparams.ds = TCR_EL2.DS;
    else
        walkparams.ds = '0';

    return walkparams;
```



## Library pseudocode for aarch64/translation/vmsa\_walkparams/AArch64.S1TTWParamsEL3

```
// AArch64.S1TTWParamsEL3()
// =====
// Gather stage 1 translation table walk parameters for EL3 regime

S1TTWParams AArch64.S1TTWParamsEL3()
    S1TTWParams walkparams;

    walkparams.tgx = AArch64.DecodeTG0(TCR_EL3.TG0);
    walkparams.txsz = TCR_EL3.T0SZ;
    walkparams.ps = TCR_EL3.PS;
    walkparams.irgn = TCR_EL3.IRGN0;
    walkparams.orgn = TCR_EL3.ORGNO;
    walkparams.sh = TCR_EL3.SH0;
    walkparams.tbi = TCR_EL3.TBI;
    walkparams.mair = MAIR_EL3;
    walkparams.wxn = SCTLR_EL3.WXN;
    walkparams.ee = SCTLR_EL3.EE;
    walkparams.sif = SCR_EL3.SIF;

    walkparams.tbid = if HavePACExt() then TCR_EL3.TBID else '0';
    walkparams.hpd = if AArch64.HaveHPDEExt() then TCR_EL3.HPD else '0';
    walkparams.ha = if HaveAccessFlagUpdateExt() then TCR_EL3.HA else '0';
    walkparams.hd = if HaveDirtyBitModifierExt() then TCR_EL3.HD else '0';
    if walkparams.tgx IN {TGx_4KB, TGx_16KB} && Have52BitIPAAAndPASpaceExt() then
        walkparams.ds = TCR_EL3.DS;
    else
        walkparams.ds = '0';

    return walkparams;
```

## Library pseudocode for aarch64/translation/vmsa\_walkparams/AArch64.S2MinTxSZ

```
// AArch64.S2MinTxSZ()
// =====
// Retrieve the minimum value of TxSZ indicating maximum input address size for stage 2

integer AArch64.S2MinTxSZ(bit ds, TGx tgx, boolean slaarch64)
    ips = AArch64.PAMax();

    if Have52BitPAExt() && tgx != TGx_64KB && ds == '0' then
        ips = Min(48, AArch64.PAMax());

    min_txsz = 64 - ips;
    if !slaarch64 then
        // EL1 is AArch32
        min_txsz = Min(min_txsz, 24);

    return min_txsz;
```

## Library pseudocode for aarch64/translation/vmsa\_walkparams/AArch64.SS2TTWParams

```
// AArch64.SS2TTWParams()
// =====
// Gather walk parameters specific for secure stage 2 translation

S2TTWParams AArch64.SS2TTWParams(PASpace ipaspace, boolean slaarch64)
    S2TTWParams walkparams;
    assert AArch64.CurrentSecurityState() == SS_Secure;

    if ipaspace == PAS_Secure then
        walkparams.tgx = AArch64.DecodeTG0(VSTCR_EL2.TG0);
        walkparams.txsz = VSTCR_EL2.T0SZ;
        walkparams.sl0 = VSTCR_EL2.SL0;
        if walkparams.tgx == TGx_4KB && Have52BitIPAAAndPASpaceExt() then
            walkparams.sl2 = VSTCR_EL2.SL2 AND VTCR_EL2.DS;
        else
            walkparams.sl2 = '0';
    elseif ipaspace == PAS_NonSecure then
        walkparams.tgx = AArch64.DecodeTG0(VTCR_EL2.TG0);
        walkparams.txsz = VTCR_EL2.T0SZ;
        walkparams.sl0 = VTCR_EL2.SL0;
        if walkparams.tgx == TGx_4KB && Have52BitIPAAAndPASpaceExt() then
            walkparams.sl2 = VTCR_EL2.SL2 AND VTCR_EL2.DS;
        else
            walkparams.sl2 = '0';
    else
        Unreachable();

    walkparams.sw = VSTCR_EL2.SW;
    walkparams.nsw = VTCR_EL2.NSW;
    walkparams.sa = VSTCR_EL2.SA;
    walkparams.nsa = VTCR_EL2.NSA;
    walkparams.vm = HCR_EL2.VM OR HCR_EL2.DC;
    walkparams.ps = VTCR_EL2.PS;
    walkparams.irgn = VTCR_EL2.IRGN0;
    walkparams.orgn = VTCR_EL2.ORGNO;
    walkparams.sh = VTCR_EL2.SH0;
    walkparams.ee = SCTLR_EL2.EE;

    walkparams.ptw = if HCR_EL2.TGE == '0' then HCR_EL2.PTW else '0';
    walkparams.fwb = if HaveStage2MemAttrControl() then HCR_EL2.FWB else '0';
    walkparams.ha = if HaveAccessFlagUpdateExt() then VTCR_EL2.HA else '0';
    walkparams.hd = if HaveDirtyBitModifierExt() then VTCR_EL2.HD else '0';
    if walkparams.tgx IN {TGx_4KB, TGx_16KB} && Have52BitIPAAAndPASpaceExt() then
        walkparams.ds = VTCR_EL2.DS;
    else
        walkparams.ds = '0';

    return walkparams;
```

## Library pseudocode for aarch64/translation/vmsa\_walkparams/AArch64.VAMax

```
// AArch64.VAMax()
// =====
// Returns the IMPLEMENTATION DEFINED maximum number of bits capable of representing
// the virtual address for this processor

integer AArch64.VAMax()
    return integer IMPLEMENTATION_DEFINED "Maximum Virtual Address Size";
```

## Library pseudocode for shared/debug/ClearStickyErrors/ClearStickyErrors

```
// ClearStickyErrors()
// =====

ClearStickyErrors()
    EDSCR.TXU = '0';           // Clear TX underrun flag
    EDSCR.RX0 = '0';           // Clear RX overrun flag

    if Halted() then           // in Debug state
        EDSCR.IT0 = '0';       // Clear ITR overrun flag

    // If halted and the ITR is not empty then it is UNPREDICTABLE whether the EDSCR.ERR is cleared.
    // The UNPREDICTABLE behavior also affects the instructions in flight, but this is not described
    // in the pseudocode.
    if Halted() && EDSCR.ITE == '0' && ConstrainUnpredictableBool(Unpredictable_CLEARERRITEZERO) then
        return;
    EDSCR.ERR = '0';           // Clear cumulative error flag

    return;
```

## Library pseudocode for shared/debug/DebugTarget/DebugTarget

```
// DebugTarget()
// =====
// Returns the debug exception target Exception level

bits(2) DebugTarget()
    secure = IsSecure();
    return DebugTargetFrom(secure);
```

## Library pseudocode for shared/debug/DebugTarget/DebugTargetFrom

```
// DebugTargetFrom()
// =====

bits(2) DebugTargetFrom(boolean secure)
    if HaveEL(EL2) && (!secure || (HaveSecureEL2Ext() && (!HaveEL(EL3) || SCR_EL3.EEL2 == '1')))) then
        if ELUsingAArch32(EL2) then
            route_to_el2 = (HDCR.TDE == '1' || HCR.TGE == '1');
        else
            route_to_el2 = (MDCR_EL2.TDE == '1' || HCR_EL2.TGE == '1');
    else
        route_to_el2 = FALSE;

    if route_to_el2 then
        target = EL2;
    elsif HaveEL(EL3) && HighestELUsingAArch32() && secure then
        target = EL3;
    else
        target = EL1;

    return target;
```

## Library pseudocode for shared/debug/DoubleLockStatus/DoubleLockStatus

```
// DoubleLockStatus()
// =====
// Returns the state of the OS Double Lock.
// FALSE if OSDLR_EL1.DLK == 0 or DBGPRCR_EL1.CORENPDRQ == 1 or the PE is in Debug state.
// TRUE if OSDLR_EL1.DLK == 1 and DBGPRCR_EL1.CORENPDRQ == 0 and the PE is in Non-debug state.

boolean DoubleLockStatus()
    if !HaveDoubleLock() then
        return FALSE;
    elsif ELUsingAArch32(EL1) then
        return DBGOSDLR.DLK == '1' && DBGPRCR.CORENPDRQ == '0' && !Halted();
    else
        return OSDLR_EL1.DLK == '1' && DBGPRCR_EL1.CORENPDRQ == '0' && !Halted();
```

## Library pseudocode for shared/debug/OSLockStatus/OSLockStatus

```
// OSLockStatus()
// =====
// Returns the state of the OS Lock.

boolean OSLockStatus()
    return (if ELUsingAArch32(EL1) then DBGOSLSR.OSLK else OSLSR_EL1.OSLK) == '1';
```

## Library pseudocode for shared/debug/SoftwareLockStatus/Component

```
enumeration Component {
    Component_PMU,
    Component_Debug,
    Component_CTI
};
```

## Library pseudocode for shared/debug/SoftwareLockStatus/GetAccessComponent

```
// Returns the accessed component.
Component GetAccessComponent();
```

## Library pseudocode for shared/debug/SoftwareLockStatus/SoftwareLockStatus

```
// SoftwareLockStatus()
// =====
// Returns the state of the Software Lock.

boolean SoftwareLockStatus()
    Component component = GetAccessComponent();
    if !HaveSoftwareLock(component) then
        return FALSE;
    case component of
        when Component_Debug
            return EDLSR.SLK == '1';
        when Component_PMU
            return PMLSR.SLK == '1';
        when Component_CTI
            return CTILSR.SLK == '1';
    otherwise
        Unreachable();
```

## Library pseudocode for shared/debug/authentication/AllowExternalDebugAccess

```
// AllowExternalDebugAccess()
// =====
// Returns TRUE if an external debug interface access to the External debug registers
// is allowed, FALSE otherwise.

boolean AllowExternalDebugAccess()
    // The access may also be subject to OS Lock, power-down, etc.
    if HaveSecureExtDebugView() then
        return AllowExternalDebugAccess(IsAccessSecure());
    else
        return AllowExternalDebugAccess(ExternalSecureInvasiveDebugEnabled());

// AllowExternalDebugAccess()
// =====
// Returns TRUE if an external debug interface access to the External debug registers
// is allowed for the given Security state, FALSE otherwise.

boolean AllowExternalDebugAccess(boolean allow_secure)
    // The access may also be subject to OS Lock, power-down, etc.
    if HaveSecureExtDebugView() || ExternalInvasiveDebugEnabled() then
        if allow_secure then
            return TRUE;
        elseif HaveEL(EL3) then
            if ELUsingAArch32(EL3) then
                return SDCR.EDAD == '0';
            else
                return MDCR_EL3.EDAD == '0';
        else
            return !IsSecure();
    else
        return FALSE;
```

## Library pseudocode for shared/debug/authentication/AllowExternalPMUAccess

```
// AllowExternalPMUAccess()
// =====
// Returns TRUE if an external debug interface access to the PMU registers is allowed, FALSE otherwise.

boolean AllowExternalPMUAccess()
    // The access may also be subject to OS Lock, power-down, etc.
    if HaveSecureExtDebugView() then
        return AllowExternalPMUAccess(IsAccessSecure());
    else
        return AllowExternalPMUAccess(ExternalSecureNoninvasiveDebugEnabled());

// AllowExternalPMUAccess()
// =====
// Returns TRUE if an external debug interface access to the PMU registers is allowed for the given
// Security state, FALSE otherwise.

boolean AllowExternalPMUAccess(boolean allow_secure)
    // The access may also be subject to OS Lock, power-down, etc.
    if HaveSecureExtDebugView() || ExternalNoninvasiveDebugEnabled() then
        if allow_secure then
            return TRUE;
        elseif HaveEL(EL3) then
            if ELUsingAArch32(EL3) then
                return SDCR.EPMAD == '0';
            else
                return MDCR_EL3.EPMAD == '0';
        else
            return !IsSecure();
    else
        return FALSE;
```

## Library pseudocode for shared/debug/authentication/Debug\_authentication

```
signal DBGEN;  
signal NIDEN;  
signal SPIDEN;  
signal SPNIDEN;
```

## Library pseudocode for shared/debug/authentication/ExternalInvasiveDebugEnabled

```
// ExternalInvasiveDebugEnabled()  
// =====  
// The definition of this function is IMPLEMENTATION DEFINED.  
// In the recommended interface, this function returns the state of the DBGEN signal.  
  
boolean ExternalInvasiveDebugEnabled()  
    return DBGEN == HIGH;
```

## Library pseudocode for shared/debug/authentication/ExternalNoninvasiveDebugEnabled

```
// ExternalNoninvasiveDebugEnabled()  
// =====  
// Returns TRUE if Trace and PC Sample-based Profiling are allowed  
  
boolean ExternalNoninvasiveDebugEnabled()  
    return (ExternalNoninvasiveDebugEnabled() &&  
            (!IsSecure() || ExternalSecureNoninvasiveDebugEnabled() ||  
             (ELUsingAArch32(EL1) && PSTATE.EL == EL0 && SDER.SUNIDEN == '1')));
```

## Library pseudocode for shared/debug/authentication/ExternalNoninvasiveDebugEnabled

```
// ExternalNoninvasiveDebugEnabled()  
// =====  
// This function returns TRUE if the FEAT_Debugv8p4 is implemented, otherwise this  
// function is IMPLEMENTATION DEFINED.  
// In the recommended interface, ExternalNoninvasiveDebugEnabled returns the state of the (DBGEN  
// OR NIDEN) signal.  
  
boolean ExternalNoninvasiveDebugEnabled()  
    return !HaveNoninvasiveDebugAuth() || ExternalInvasiveDebugEnabled() || NIDEN == HIGH;
```

## Library pseudocode for shared/debug/authentication/ExternalSecureInvasiveDebugEnabled

```
// ExternalSecureInvasiveDebugEnabled()  
// =====  
// The definition of this function is IMPLEMENTATION DEFINED.  
// In the recommended interface, this function returns the state of the (DBGEN AND SPIDEN) signal.  
// CoreSight allows asserting SPIDEN without also asserting DBGEN, but this is not recommended.  
  
boolean ExternalSecureInvasiveDebugEnabled()  
    if !HaveEL(EL3) && !IsSecure() then return FALSE;  
    return ExternalInvasiveDebugEnabled() && SPIDEN == HIGH;
```

## Library pseudocode for shared/debug/authentication/ExternalSecureNoninvasiveDebugEnabled

```
// ExternalSecureNoninvasiveDebugEnabled()
// =====
// This function returns the value of ExternalSecureInvasiveDebugEnabled() when FEAT_Debugv8p4
// is implemented. Otherwise, the definition of this function is IMPLEMENTATION DEFINED.
// In the recommended interface, this function returns the state of the (DBGEN OR NIDEN) AND
// (SPIDEN OR SPNIDEN) signal.

boolean ExternalSecureNoninvasiveDebugEnabled()
    if !HaveEL(EL3) && !IsSecure() then return FALSE;
    if HaveNoninvasiveDebugAuth() then
        return ExternalNoninvasiveDebugEnabled() && (SPIDEN == HIGH || SPNIDEN == HIGH);
    else
        return ExternalSecureInvasiveDebugEnabled();
```

## Library pseudocode for shared/debug/authentication/IsAccessSecure

```
// Returns TRUE when an access is Secure
boolean IsAccessSecure();
```

## Library pseudocode for shared/debug/authentication/IsCorePowered

```
// Returns TRUE if the Core power domain is powered on, FALSE otherwise.
boolean IsCorePowered();
```

## Library pseudocode for shared/debug/breakpoint/CheckValidStateMatch

```
// CheckValidStateMatch()
// =====
// Checks for an invalid state match that will generate Constrained Unpredictable behaviour, otherwise
// returns Constraint_NONE.

(Constraint, bits(2), bit, bits(2)) CheckValidStateMatch(bits(2) SSC, bit HMC, bits(2) PxC, boolean isbreakpoint,
boolean reserved = FALSE;

// Match 'Usr/Sys/Svc' only valid for AArch32 breakpoints
if (!isbreakpoint || !HaveAArch32EL(EL1)) && HMC:PxC == '000' && SSC != '11' then
    reserved = TRUE;

// Both EL3 and EL2 are not implemented
if !HaveEL(EL3) && !HaveEL(EL2) && (HMC != '0' || SSC != '00') then
    reserved = TRUE;

// EL3 is not implemented
if !HaveEL(EL3) && SSC IN {'01','10'} && HMC:SSC:PxC != '10100' then
    reserved = TRUE;

// EL3 using AArch64 only
if (!HaveEL(EL3) || HighestELUsingAArch32()) && HMC:SSC:PxC == '11000' then
    reserved = TRUE;

// EL2 is not implemented
if !HaveEL(EL2) && HMC:SSC:PxC == '11100' then
    reserved = TRUE;

// Secure EL2 is not implemented
if !HaveSecureEL2Ext() && (HMC:SSC:PxC) IN {'01100','10100','x11x1'} then
    reserved = TRUE;

// Values that are not allocated in any architecture version
if (HMC:SSC:PxC) IN {'01110','100x0','10110','11x10'} then
    reserved = TRUE;

if reserved then
    // If parameters are set to a reserved type, behaves as either disabled or a defined type
    (c, <HMC,SSC,PxC>) = ConstrainUnpredictableBits(Unpredictable_RESBPWPCTRL);
    assert c IN {Constraint_DISABLED, Constraint_UNKNOWN};
    if c == Constraint_DISABLED then
        return (c, bits(2) UNKNOWN, bit UNKNOWN, bits(2) UNKNOWN);
    // Otherwise the value returned by ConstrainUnpredictableBits must be a not-reserved value

return (Constraint_NONE, SSC, HMC, PxC);
```

## Library pseudocode for shared/debug/breakpoint/GetNumBreakpoints

```
// GetNumBreakpoints()
// =====
// Returns the number of breakpoints implemented. This is indicated to software by
// DBGDIDR.BRPs in AArch32 state, and ID_AA64DFR0_EL1.BRPs in AArch64 state.

integer GetNumBreakpoints()
    return integer IMPLEMENTATION_DEFINED "Number of breakpoints";
```

## Library pseudocode for shared/debug/breakpoint/GetNumContextAwareBreakpoints

```
// GetNumContextAwareBreakpoints()
// =====
// Returns the number of context-aware breakpoints implemented. This is indicated to software by
// DBGDIDR.CTX_CMPs in AArch32 state, and ID_AA64DFR0_EL1.CTX_CMPs in AArch64 state.

integer GetNumContextAwareBreakpoints()
    return integer IMPLEMENTATION_DEFINED "Number of context-aware breakpoints";
```



## Library pseudocode for shared/debug/breakpoint/GetNumWatchpoints

```
// GetNumWatchpoints()
// =====
// Returns the number of watchpoints implemented. This is indicated to software by
// DBGDIDR.WRPs in AArch32 state, and ID_AA64DFR0_EL1.WRPs in AArch64 state.

integer GetNumWatchpoints()
    return integer IMPLEMENTATION_DEFINED "Number of watchpoints";
```

## Library pseudocode for shared/debug/cti/CTI\_SetEventLevel

```
// Set a Cross Trigger multi-cycle input event trigger to the specified level.
CTI_SetEventLevel(CrossTriggerIn id, signal level);
```

## Library pseudocode for shared/debug/cti/CTI\_SignalEvent

```
// Signal a discrete event on a Cross Trigger input event trigger.
CTI_SignalEvent(CrossTriggerIn id);
```

## Library pseudocode for shared/debug/cti/CrossTrigger

```
enumeration CrossTriggerOut {CrossTriggerOut_DebugRequest, CrossTriggerOut_RestartRequest,
                             CrossTriggerOut_IRQ,           CrossTriggerOut_RSVD3,
                             CrossTriggerOut_TraceExtIn0,    CrossTriggerOut_TraceExtIn1,
                             CrossTriggerOut_TraceExtIn2,    CrossTriggerOut_TraceExtIn3};

enumeration CrossTriggerIn  {CrossTriggerIn_CrossHalt,      CrossTriggerIn_PMUOverflow,
                             CrossTriggerIn_RSVD2,         CrossTriggerIn_RSVD3,
                             CrossTriggerIn_TraceExtOut0,   CrossTriggerIn_TraceExtOut1,
                             CrossTriggerIn_TraceExtOut2,   CrossTriggerIn_TraceExtOut3};
```

## Library pseudocode for shared/debug/dccanditr/CheckForDCCInterrupts

```
// CheckForDCCInterrupts()
// =====

CheckForDCCInterrupts()
    commrx = (EDSCR.RXfull == '1');
    commtx = (EDSCR.TXfull == '0');

    // COMMRX and COMMTX support is optional and not recommended for new designs.
    // SetInterruptRequestLevel(InterruptID_COMMRX, if commrx then HIGH else LOW);
    // SetInterruptRequestLevel(InterruptID_COMMTX, if commtx then HIGH else LOW);

    // The value to be driven onto the common COMMIRQ signal.
    if ELUsingAArch32\(EL1\) then
        commirq = ((commrx && DBGDCCINT.RX == '1') ||
                   (commtx && DBGDCCINT.TX == '1'));
    else
        commirq = ((commrx && MDCCINT_EL1.RX == '1') ||
                   (commtx && MDCCINT_EL1.TX == '1'));
    SetInterruptRequestLevel(InterruptID\_COMMIRQ, if commirq then HIGH else LOW);

    return;
```

## Library pseudocode for shared/debug/dccanditr/DBGDTRRX\_EL0

```
// DBGDTRRX_EL0[] (external write)
// =====
// Called on writes to debug register 0x08C.

DBGDTRRX_EL0[boolean memory_mapped] = bits(32) value

if EDPRSR<6:5,0> != '001' then // Check DLK, OSLK and PU bits
    IMPLEMENTATION_DEFINED "generate error response";
    return;

if EDSCR.ERR == '1' then return; // Error flag set: ignore write

// The Software lock is OPTIONAL.
if memory_mapped && EDLSR.SLK == '1' then return; // Software lock locked: ignore write

if EDSCR.RXfull == '1' || (Halted() && EDSCR.MA == '1' && EDSCR.ITE == '0') then
    EDSCR.RX0 = '1'; EDSCR.ERR = '1'; // Overrun condition: ignore write
    return;

EDSCR.RXfull = '1';
DTRRX = value;

if Halted() && EDSCR.MA == '1' then
    EDSCR.ITE = '0'; // See comments in EDITR[] (external write)
    if !UsingAArch32() then
        ExecuteA64(0xD5330501<31:0>); // A64 "MRS X1,DBGDTRRX_EL0"
        ExecuteA64(0xB8004401<31:0>); // A64 "STR W1,[X0],#4"
        X[1] = bits(64) UNKNOWN;
    else
        ExecuteT32(0xEE10<15:0> /*hw1*/, 0x1E15<15:0> /*hw2*/); // T32 "MRS R1,DBGDTRRXint"
        ExecuteT32(0xF840<15:0> /*hw1*/, 0x1B04<15:0> /*hw2*/); // T32 "STR R1,[R0],#4"
        R[1] = bits(32) UNKNOWN;
    // If the store aborts, the Data Abort exception is taken and EDSCR.ERR is set to 1
    if EDSCR.ERR == '1' then
        EDSCR.RXfull = bit UNKNOWN;
        DBGDTRRX_EL0 = bits(64) UNKNOWN;
    else
        // "MRS X1,DBGDTRRX_EL0" calls DBGDTR_EL0[] (read) which clears RXfull.
        assert EDSCR.RXfull == '0';

    EDSCR.ITE = '1'; // See comments in EDITR[] (external write)
    return;

// DBGDTRRX_EL0[] (external read)
// =====

bits(32) DBGDTRRX_EL0[boolean memory_mapped]
return DTRRX;
```

## Library pseudocode for shared/debug/dccanditr/DBGDTRTX\_EL0

```
// DBGDTRTX_EL0[] (external read)
// =====
// Called on reads of debug register 0x080.

bits(32) DBGDTRTX_EL0[boolean memory_mapped]

    if EDPRSR<6:5,0> != '001' then // Check DLK, OSLK and PU bits
        IMPLEMENTATION_DEFINED "generate error response";
        return bits(32) UNKNOWN;

    underrun = EDSCR.TXfull == '0' || (Halted() && EDSCR.MA == '1' && EDSCR.ITE == '0');
    value = if underrun then bits(32) UNKNOWN else DTRTX;

    if EDSCR.ERR == '1' then return value; // Error flag set: no side-effects

    // The Software lock is OPTIONAL.
    if memory_mapped && EDLSR.SLK == '1' then // Software lock locked: no side-effects
        return value;

    if underrun then
        EDSCR.TXU = '1'; EDSCR.ERR = '1'; // Underrun condition: block side-effects
        return value; // Return UNKNOWN

    EDSCR.TXfull = '0';
    if Halted() && EDSCR.MA == '1' then
        EDSCR.ITE = '0'; // See comments in EDITR[] (external write)

    if !UsingAArch32() then
        ExecuteA64(0xB8404401<31:0>); // A64 "LDR W1,[X0],#4"
    else
        ExecuteT32(0xF850<15:0> /*hw1*/, 0x1B04<15:0> /*hw2*/); // T32 "LDR R1,[R0],#4"
    // If the load aborts, the Data Abort exception is taken and EDSCR.ERR is set to 1
    if EDSCR.ERR == '1' then
        EDSCR.TXfull = bit UNKNOWN;
        DBGDTRTX_EL0 = bits(64) UNKNOWN;
    else
        if !UsingAArch32() then
            ExecuteA64(0xD5130501<31:0>); // A64 "MSR DBGDTRTX_EL0,X1"
        else
            ExecuteT32(0xEE00<15:0> /*hw1*/, 0x1E15<15:0> /*hw2*/); // T32 "MSR DBGDTRTXint,R1"
        // "MSR DBGDTRTX_EL0,X1" calls DBGDTR_EL0[] (write) which sets TXfull.
        assert EDSCR.TXfull == '1';
    if !UsingAArch32() then
        X[1] = bits(64) UNKNOWN;
    else
        R[1] = bits(32) UNKNOWN;
    EDSCR.ITE = '1'; // See comments in EDITR[] (external write)

    return value;

// DBGDTRTX_EL0[] (external write)
// =====

DBGDTRTX_EL0[boolean memory_mapped] = bits(32) value
// The Software lock is OPTIONAL.
if memory_mapped && EDLSR.SLK == '1' then return; // Software lock locked: ignore write
DTRTX = value;
return;
```

## Library pseudocode for shared/debug/dccanditr/DBGDTR\_EL0

```
// DBGDTR_EL0[] (write)
// =====
// System register writes to DBGDTR_EL0, DBGDTRTX_EL0 (AArch64) and DBGDTRTXint (AArch32)

DBGDTR_EL0[] = bits(N) value
  // For MSR DBGDTRTX_EL0,<Rt>  N=32, value=X[t]<31:0>, X[t]<63:32> is ignored
  // For MSR DBGDTR_EL0,<Xt>    N=64, value=X[t]<63:0>
  assert N IN {32,64};
  if EDSCR.TXfull == '1' then
    value = bits(N) UNKNOWN;
  // On a 64-bit write, implement a half-duplex channel
  if N == 64 then DTRRX = value<63:32>;
  DTRTX = value<31:0>;          // 32-bit or 64-bit write
  EDSCR.TXfull = '1';
  return;

// DBGDTR_EL0[] (read)
// =====
// System register reads of DBGDTR_EL0, DBGDTRRX_EL0 (AArch64) and DBGDTRRXint (AArch32)

bits(N) DBGDTR_EL0[]
  // For MRS <Rt>,DBGDTRTX_EL0  N=32, X[t]=Zeros(32):result
  // For MRS <Xt>,DBGDTR_EL0    N=64, X[t]=result
  assert N IN {32,64};
  bits(N) result;
  if EDSCR.RXfull == '0' then
    result = bits(N) UNKNOWN;
  else
    // On a 64-bit read, implement a half-duplex channel
    // NOTE: the word order is reversed on reads with regards to writes
    if N == 64 then result<63:32> = DTRTX;
    result<31:0> = DTRRX;
  EDSCR.RXfull = '0';
  return result;
```

## Library pseudocode for shared/debug/dccanditr/DTR

```
bits(32) DTRRX;
bits(32) DTRTX;
```

## Library pseudocode for shared/debug/dccanditr/EDITR

```
// EDITR[] (external write)
// =====
// Called on writes to debug register 0x084.

EDITR[boolean memory_mapped] = bits(32) value
  if EDPRSR<6:5,0> != '001' then                                // Check DLK, OSLK and PU bits
    IMPLEMENTATION_DEFINED "generate error response";
    return;

  if EDSCR.ERR == '1' then return;                               // Error flag set: ignore write

  // The Software lock is OPTIONAL.
  if memory_mapped && EDLSR.SLK == '1' then return;             // Software lock locked: ignore write

  if !Halted() then return;                                     // Non-debug state: ignore write

  if EDSCR.ITE == '0' || EDSCR.MA == '1' then
    EDSCR.ITO = '1'; EDSCR.ERR = '1';                           // Overrun condition: block write
    return;

  // ITE indicates whether the processor is ready to accept another instruction; the processor
  // may support multiple outstanding instructions. Unlike the "InstrCompl" flag in [v7A] there
  // is no indication that the pipeline is empty (all instructions have completed). In this
  // pseudocode, the assumption is that only one instruction can be executed at a time,
  // meaning ITE acts like "InstrCompl".
  EDSCR.ITE = '0';

  if !UsingAArch32() then
    ExecuteA64(value);
  else
    ExecuteT32(value<15:0> /*hw1*/, value<31:16> /*hw2*/);

  EDSCR.ITE = '1';

return;
```



```

// DCPSInstruction()
// =====
// Operation of the DCPS instruction in Debug state

DCPSInstruction(bits(2) target_el)

    SynchronizeContext();

case target_el of
    when EL1
        if PSTATE.EL == EL2 || (PSTATE.EL == EL3 && !UsingAArch32()) then handle_el = PSTATE.EL;
        elsif EL2Enabled() && HCR_EL2.TGE == '1' then UNDEFINED;
        else handle_el = EL1;

    when EL2
        if !HaveEL(EL2) then UNDEFINED;
        elsif PSTATE.EL == EL3 && !UsingAArch32() then handle_el = EL3;
        elsif !IsSecureEL2Enabled() && IsSecure() then UNDEFINED;
        else handle_el = EL2;

    when EL3
        if EDSCR.SDD == '1' || !HaveEL(EL3) then UNDEFINED;
        handle_el = EL3;
    otherwise
        Unreachable();

from_secure = IsSecure();
if ELUsingAArch32(handle_el) then
    if PSTATE.M == M32_Monitor then SCR.NS = '0';
    assert UsingAArch32(); // Cannot move from AArch64 to AArch32
    case handle_el of
        when EL1
            AArch32.WriteMode(M32_Svc);
            if HavePANExt() && SCTL.R.SPAN == '0' then
                PSTATE.PAN = '1';
        when EL2
            AArch32.WriteMode(M32_Hyp);
        when EL3
            AArch32.WriteMode(M32_Monitor);
            if HavePANExt() then
                if !from_secure then
                    PSTATE.PAN = '0';
                elsif SCTL.R.SPAN == '0' then
                    PSTATE.PAN = '1';
    if handle_el == EL2 then
        ELR_hyp = bits(32) UNKNOWN; HSR = bits(32) UNKNOWN;
    else
        LR = bits(32) UNKNOWN;
        SPSR[] = bits(32) UNKNOWN;
        PSTATE.E = SCTL.R.EE;
        DLR = bits(32) UNKNOWN; DSPSR = bits(32) UNKNOWN;

else // Targeting AArch64
    if UsingAArch32() then
        AArch64.MaybeZeroRegisterUppers();
        MaybeZeroSVEUppers(target_el);
        PSTATE.nRW = '0'; PSTATE.SP = '1'; PSTATE.EL = handle_el;
        if HavePANExt() && ((handle_el == EL1 && SCTL.R_EL1.SPAN == '0') ||
            (handle_el == EL2 && HCR_EL2.E2H == '1' &&
            HCR_EL2.TGE == '1' && SCTL.R_EL2.SPAN == '0')) then
            PSTATE.PAN = '1';
        ELR[] = bits(64) UNKNOWN; SPSR[] = bits(64) UNKNOWN; ESR[] = bits(64) UNKNOWN;
        DLR_EL0 = bits(64) UNKNOWN; DSPSR_EL0 = bits(64) UNKNOWN;
        if HaveUA0Ext() then PSTATE.UA0 = '0';
        if HaveMTEExt() then PSTATE.TCO = '1';

UpdateEDSCRFields(); // Update EDSCR PE state flags
sync_errors = HaveIESB() && SCTL.R.IESB == '1';
if HaveDoubleFaultExt() && !UsingAArch32() then
    sync_errors = sync_errors || (SCR_EL3.EA == '1' && SCR_EL3.NMEA == '1' && PSTATE.EL == EL3);
// SCTL.R.IESB might be ignored in Debug state.
if !ConstrainUnpredictableBool(Unpredictable_IESBinDebug) then

```

```

    sync_errors = FALSE;
if sync_errors then
    SynchronizeErrors();
return;

```

## Library pseudocode for shared/debug/halting/DRPSInstruction

```

// DRPSInstruction()
// =====
// Operation of the A64 DRPS and T32 ERET instructions in Debug state

DRPSInstruction()

    SynchronizeContext();

    sync_errors = HaveIESB() && SCTLRL[.IESB == '1';
if HaveDoubleFaultExt() && !UsingAArch32() then
    sync_errors = sync_errors || (SCR_EL3.EA == '1' && SCR_EL3.NMEA == '1' && PSTATE.EL == EL3);
// SCTLRL[.IESB might be ignored in Debug state.
if !ConstrainUnpredictableBool(Unpredictable_IESBinDebug) then
    sync_errors = FALSE;
if sync_errors then
    SynchronizeErrors();

    bits(64) spsr = SPSR[];
    SetPSTATEFromPSR(spsr);

// PSTATE.{N,Z,C,V,Q,GE,SS,D,A,I,F} are not observable and ignored in Debug state, so
// behave as if UNKNOWN.
if UsingAArch32() then
    PSTATE.<N,Z,C,V,Q,GE,SS,A,I,F> = bits(13) UNKNOWN;
// In AArch32, all instructions are T32 and unconditional.
PSTATE.IT = '00000000'; PSTATE.T = '1'; // PSTATE.J is RES0
DLR = bits(32) UNKNOWN; DSPSR = bits(32) UNKNOWN;
else
    PSTATE.<N,Z,C,V,SS,D,A,I,F> = bits(9) UNKNOWN;
    DLR_EL0 = bits(64) UNKNOWN; DSPSR_EL0 = bits(64) UNKNOWN;

    UpdateEDSCRFields(); // Update EDSCR PE state flags

return;

```

## Library pseudocode for shared/debug/halting/DebugHalt

```

constant bits(6) DebugHalt_Breakpoint      = '000111';
constant bits(6) DebugHalt_EDBGRQ         = '010011';
constant bits(6) DebugHalt_Step_Normal     = '011011';
constant bits(6) DebugHalt_Step_Exclusive = '011111';
constant bits(6) DebugHalt_OSUnlockCatch   = '100011';
constant bits(6) DebugHalt_ResetCatch      = '100111';
constant bits(6) DebugHalt_Watchpoint      = '101011';
constant bits(6) DebugHalt_HaltInstruction = '101111';
constant bits(6) DebugHalt_SoftwareAccess  = '110011';
constant bits(6) DebugHalt_ExceptionCatch  = '110111';
constant bits(6) DebugHalt_Step_NoSyndrome = '111011';

```

## Library pseudocode for shared/debug/halting/DisableITRAndResumeInstructionPrefetch

```

DisableITRAndResumeInstructionPrefetch();

```

## Library pseudocode for shared/debug/halting/ExecuteA64

```

// Execute an A64 instruction in Debug state.
ExecuteA64(bits(32) instr);

```



## Library pseudocode for shared/debug/halting/ExecuteT32

```
// Execute a T32 instruction in Debug state.  
ExecuteT32(bits(16) hw1, bits(16) hw2);
```

## Library pseudocode for shared/debug/halting/ExitDebugState

```
// ExitDebugState()  
// =====  
  
ExitDebugState()  
    assert Halted();  
    SynchronizeContext();  
  
    // Although EDSCR.STATUS signals that the PE is restarting, debuggers must use EDPRSR.SDR to  
    // detect that the PE has restarted.  
    EDSCR.STATUS = '000001'; // Signal restarting  
    EDESR<2:0> = '000'; // Clear any pending Halting debug events  
  
    bits(64) new_pc;  
    bits(64) spsr;  
  
    if UsingAArch32() then  
        new_pc = ZeroExtend(DLR);  
        spsr = ZeroExtend(DSPSR);  
    else  
        new_pc = DLR_EL0;  
        spsr = DSPSR_EL0;  
    // If this is an illegal return, SetPSTATEFromPSR() will set PSTATE.IL.  
    if UsingAArch32() then  
        SetPSTATEFromPSR(spsr<31:0>); // Can update privileged bits, even at EL0  
    else  
        SetPSTATEFromPSR(spsr); // Can update privileged bits, even at EL0  
  
    boolean branch_conditional = FALSE;  
    if UsingAArch32() then  
        if ConstrainUnpredictableBool(Unpredictable_RESTARTALIGNPC) then new_pc<0> = '0';  
        // AArch32 branch  
        BranchTo(new_pc<31:0>, BranchType_DBGEXIT, branch_conditional);  
    else  
        // If targeting AArch32 then possibly zero the 32 most significant bits of the target PC  
        if spsr<4> == '1' && ConstrainUnpredictableBool(Unpredictable_RESTARTZEROUPPERPC) then  
            new_pc<63:32> = Zeros();  
        // A type of branch that is never predicted  
        BranchTo(new_pc, BranchType_DBGEXIT, branch_conditional);  
  
    (EDSCR.STATUS, EDPRSR.SDR) = ('000010', '1'); // Atomically signal restarted  
    UpdateEDSCRFields(); // Stop signalling PE state  
    DisableITRAndResumeInstructionPrefetch();  
  
    return;
```

## Library pseudocode for shared/debug/halting/Halt

```
// Halt()
// =====

Halt(bits(6) reason)

    CTI_SignalEvent(CrossTriggerIn_CrossHalt); // Trigger other cores to halt

    bits(64) preferred_restart_address = ThisInstrAddr();
    bits(32) spsr_32;
    bits(64) spsr_64;
    if UsingAArch32() then
        spsr_32 = GetPSRFromPSTATE(DebugState);
    else
        spsr_64 = GetPSRFromPSTATE(DebugState);

    if (HaveBTIExt() &&
        !(reason IN {DebugHalt_Step_Normal, DebugHalt_Step_Exclusive, DebugHalt_Step_NoSyndrome,
                    DebugHalt_Breakpoint, DebugHalt_HaltInstruction}) &&
        ConstrainUnpredictableBool(Unpredictable_ZEROBTPE)) then
        if UsingAArch32() then
            spsr_32<11:10> = '00';
        else
            spsr_64<11:10> = '00';

    if UsingAArch32() then
        DLR = preferred_restart_address<31:0>;
        DSPSR = spsr_32;
    else
        DLR_EL0 = preferred_restart_address;
        DSPSR_EL0 = spsr_64;

    EDSCR.ITE = '1';
    EDSCR.IT0 = '0';
    if IsSecure() then
        EDSCR.SDD = '0'; // If entered in Secure state, allow debug
    elseif HaveEL(EL3) then
        EDSCR.SDD = if ExternalSecureInvasiveDebugEnabled() then '0' else '1';
    else
        assert EDSCR.SDD == '1'; // Otherwise EDSCR.SDD is RES1
    EDSCR.MA = '0';

    // In Debug state:
    // * PSTATE.{SS,SSBS,D,A,I,F} are not observable and ignored so behave-as-if UNKNOWN.
    // * PSTATE.{N,Z,C,V,Q,GE,E,M,nRW,EL,SP,DIT} are also not observable, but since these
    //   are not changed on exception entry, this function also leaves them unchanged.
    // * PSTATE.{IT,T} are ignored.
    // * PSTATE.IL is ignored and behave-as-if 0.
    // * PSTATE.BTYPE is ignored and behave-as-if 0.
    // * PSTATE.TCO is set 1.
    // * PSTATE.{UA0,PAN} are observable and not changed on entry into Debug state.
    if UsingAArch32() then
        PSTATE.<IT,SS,SSBS,A,I,F,T> = bits(14) UNKNOWN;
    else
        PSTATE.<SS,SSBS,D,A,I,F> = bits(6) UNKNOWN;
        PSTATE.TCO = '1';
        PSTATE.BTYPE = '00';
    PSTATE.IL = '0';

    StopInstructionPrefetchAndEnableITR();
    EDSCR.STATUS = reason; // Signal entered Debug state
    UpdateEDSCRFields(); // Update EDSCR PE state flags.

return;
```

### Library pseudocode for shared/debug/halting/HaltOnBreakpointOrWatchpoint

```
// HaltOnBreakpointOrWatchpoint()
// =====
// Returns TRUE if the Breakpoint and Watchpoint debug events should be considered for Debug
// state entry, FALSE if they should be considered for a debug exception.

boolean HaltOnBreakpointOrWatchpoint()
    return HaltingAllowed() && EDSCR.HDE == '1' && OSLSR_EL1.OSLK == '0';
```

### Library pseudocode for shared/debug/halting/Halted

```
// Halted()
// =====

boolean Halted()
    return !(EDSCR.STATUS IN {'000001', '000010'}); // Halted
```

### Library pseudocode for shared/debug/halting/HaltingAllowed

```
// HaltingAllowed()
// =====
// Returns TRUE if halting is currently allowed, FALSE if halting is prohibited.

boolean HaltingAllowed()
    if Halted() || DoubleLockStatus() then
        return FALSE;
    elseif IsSecure() then
        return ExternalSecureInvasiveDebugEnabled();
    else
        return ExternalInvasiveDebugEnabled();
```

### Library pseudocode for shared/debug/halting/Restarting

```
// Restarting()
// =====

boolean Restarting()
    return EDSCR.STATUS == '000001'; // Restarting
```

### Library pseudocode for shared/debug/halting/StopInstructionPrefetchAndEnableITR

```
StopInstructionPrefetchAndEnableITR();
```

## Library pseudocode for shared/debug/halting/UpdateEDSCRFields

```
// UpdateEDSCRFields()
// =====
// Update EDSCR PE state fields

UpdateEDSCRFields()

    if !Halted() then
        EDSCR.EL = '00';
        EDSCR.NS = bit UNKNOWN;
        EDSCR.RW = '1111';
    else
        EDSCR.EL = PSTATE.EL;
        EDSCR.NS = if IsSecure() then '0' else '1';

        bits(4) RW;
        RW<1> = if ELUsingAArch32(EL1) then '0' else '1';
        if PSTATE.EL != EL0 then
            RW<0> = RW<1>;
        else
            RW<0> = if UsingAArch32() then '0' else '1';
        if !HaveEL(EL2) || (HaveEL(EL3) && SCR_GEN[].NS == '0' && !IsSecureEL2Enabled()) then
            RW<2> = RW<1>;
        else
            RW<2> = if ELUsingAArch32(EL2) then '0' else '1';
        if !HaveEL(EL3) then
            RW<3> = RW<2>;
        else
            RW<3> = if ELUsingAArch32(EL3) then '0' else '1';

        // The least-significant bits of EDSCR.RW are UNKNOWN if any higher EL is using AArch32.
        if RW<3> == '0' then RW<2:0> = bits(3) UNKNOWN;
        elsif RW<2> == '0' then RW<1:0> = bits(2) UNKNOWN;
        elsif RW<1> == '0' then RW<0> = bit UNKNOWN;
        EDSCR.RW = RW;
    return;
```

## Library pseudocode for shared/debug/haltingevents/CheckExceptionCatch

```
// CheckExceptionCatch()
// =====
// Check whether an Exception Catch debug event is set on the current Exception level

CheckExceptionCatch(boolean exception_entry)
    // Called after an exception entry or exit, that is, such that IsSecure() and PSTATE.EL are correct
    // for the exception target.
    base = if IsSecure() then 0 else 4;
    if HaltingAllowed() then
        if HaveExtendedECDebugEvents() then
            exception_exit = !exception_entry;
            ctrl = EDECCR<UInt>(PSTATE.EL) + base + 8>:EDECCR<UInt>(PSTATE.EL) + base>;
            case ctrl of
                when '00' halt = FALSE;
                when '01' halt = TRUE;
                when '10' halt = (exception_exit == TRUE);
                when '11' halt = (exception_entry == TRUE);
        else
            halt = (EDECCR<UInt>(PSTATE.EL) + base> == '1');
    if halt then Halt(DebugHalt_ExceptionCatch);
```

### Library pseudocode for shared/debug/haltingevents/CheckHaltingStep

```
// CheckHaltingStep()
// =====
// Check whether EDESR.SS has been set by Halting Step

CheckHaltingStep()
    if HaltingAllowed() && EDESR.SS == '1' then
        // The STATUS code depends on how we arrived at the state where EDESR.SS == 1.
        if HaltingStep_DidNotStep() then
            Halt(DebugHalt_Step_NoSyndrome);
        elseif HaltingStep_SteppedEX() then
            Halt(DebugHalt_Step_Exclusive);
        else
            Halt(DebugHalt_Step_Normal);
```

### Library pseudocode for shared/debug/haltingevents/CheckOSUnlockCatch

```
// CheckOSUnlockCatch()
// =====
// Called on unlocking the OS Lock to pend an OS Unlock Catch debug event

CheckOSUnlockCatch()

    if (HaveDoPD() && CTIDEVCTL.OSUCE == '1')
    || (!HaveDoPD() && EDECR.OSUCE == '1')
    then
        if !Halted() then EDESR.OSUC = '1';
```

### Library pseudocode for shared/debug/haltingevents/CheckPendingOSUnlockCatch

```
// CheckPendingOSUnlockCatch()
// =====
// Check whether EDESR.OSUC has been set by an OS Unlock Catch debug event

CheckPendingOSUnlockCatch()
    if HaltingAllowed() && EDESR.OSUC == '1' then
        Halt(DebugHalt_OSUnlockCatch);
```

### Library pseudocode for shared/debug/haltingevents/CheckPendingResetCatch

```
// CheckPendingResetCatch()
// =====
// Check whether EDESR.RC has been set by a Reset Catch debug event

CheckPendingResetCatch()
    if HaltingAllowed() && EDESR.RC == '1' then
        Halt(DebugHalt_ResetCatch);
```

### Library pseudocode for shared/debug/haltingevents/CheckResetCatch

```
// CheckResetCatch()
// =====
// Called after reset

CheckResetCatch()
    if (HaveDoPD() && CTIDEVCTL.RCE == '1') || (!HaveDoPD() && EDECR.RCE == '1') then
        EDESR.RC = '1';
        // If halting is allowed then halt immediately
        if HaltingAllowed() then Halt(DebugHalt_ResetCatch);
```

## Library pseudocode for shared/debug/haltingevents/CheckSoftwareAccessToDebugRegisters

```
// CheckSoftwareAccessToDebugRegisters()
// =====
// Check for access to Breakpoint and Watchpoint registers.

CheckSoftwareAccessToDebugRegisters()
    os_lock = (if ELUsingAArch32\(EL1\) then DBG0SLSR.OSLK else OSLSR_EL1.OSLK);
    if HaltingAllowed\(\) && EDCR.TDA == '1' && os_lock == '0' then
        Halt\(DebugHalt\_SoftwareAccess\);
```

## Library pseudocode for shared/debug/haltingevents/ExternalDebugRequest

```
// ExternalDebugRequest()
// =====

ExternalDebugRequest()
    if HaltingAllowed\(\) then
        Halt\(DebugHalt\_EDBGRQ\);
    // Otherwise the CTI continues to assert the debug request until it is taken.
```

## Library pseudocode for shared/debug/haltingevents/HaltingStep\_DidNotStep

```
// Returns TRUE if the previously executed instruction was executed in the inactive state, that is,
// if it was not itself stepped.
boolean HaltingStep_DidNotStep();
```

## Library pseudocode for shared/debug/haltingevents/HaltingStep\_SteppedEX

```
// Returns TRUE if the previously executed instruction was a Load-Exclusive class instruction
// executed in the active-not-pending state.
boolean HaltingStep_SteppedEX();
```

## Library pseudocode for shared/debug/haltingevents/RunHaltingStep

```
// RunHaltingStep()
// =====

RunHaltingStep(boolean exception_generated, bits(2) exception_target, boolean syscall,
               boolean reset)
    // "exception_generated" is TRUE if the previous instruction generated a synchronous exception
    // or was cancelled by an asynchronous exception.
    //
    // if "exception_generated" is TRUE then "exception_target" is the target of the exception, and
    // "syscall" is TRUE if the exception is a synchronous exception where the preferred return
    // address is the instruction following that which generated the exception.
    //
    // "reset" is TRUE if exiting reset state into the highest EL.

    if reset then assert !Halted\(\); // Cannot come out of reset halted
    active = EDCR.SS == '1' && !Halted\(\);

    if active && reset then // Coming out of reset with EDCR.SS set
        EDCR.SS = '1';
    elseif active && HaltingAllowed\(\) then
        if exception_generated && exception_target == EL3 then
            advance = syscall || ExternalSecureInvasiveDebugEnabled\(\);
        else
            advance = TRUE;
        if advance then EDCR.SS = '1';

    return;
```

## Library pseudocode for shared/debug/interrupts/ExternalDebugInterruptsDisabled

```
// ExternalDebugInterruptsDisabled()
// =====
// Determine whether EDSCR disables interrupts routed to 'target'.

boolean ExternalDebugInterruptsDisabled(bits(2) target)
    if Havev8p4Debug() then
        if target == EL3 || IsSecure() then
            int_dis = (EDSCR.INTdis[0] == '1' && ExternalSecureInvasiveDebugEnabled());
        else
            int_dis = (EDSCR.INTdis[0] == '1');
    else
        case target of
            when EL3
                int_dis = (EDSCR.INTdis == '11' && ExternalSecureInvasiveDebugEnabled());
            when EL2
                int_dis = (EDSCR.INTdis == '1x' && ExternalInvasiveDebugEnabled());
            when EL1
                if IsSecure() then
                    int_dis = (EDSCR.INTdis == '1x' && ExternalSecureInvasiveDebugEnabled());
                else
                    int_dis = (EDSCR.INTdis != '00' && ExternalInvasiveDebugEnabled());
    return int_dis;
```

## Library pseudocode for shared/debug/interrupts/InterruptID

```
enumeration InterruptID {InterruptID_PMUIRQ, InterruptID_COMMIRQ, InterruptID_CTIIRQ,
                        InterruptID_COMMRX, InterruptID_COMMTX};
```

## Library pseudocode for shared/debug/interrupts/SetInterruptRequestLevel

```
// Set a level-sensitive interrupt to the specified level.
SetInterruptRequestLevel(InterruptID id, signal level);
```

## Library pseudocode for shared/debug/pmu/GetNumEventCounters

```
// GetNumEventCounters()
// =====
// Returns the number of event counters implemented. This is indicated to software at the
// highest Exception level by PMCR.N in AArch32 state, and PMCR_EL0.N in AArch64 state.

integer GetNumEventCounters()
    return integer IMPLEMENTATION_DEFINED "Number of event counters";
```

## Library pseudocode for shared/debug/samplebasedprofiling/CreatePCSample

```
// CreatePCSample()
// =====

CreatePCSample()
// In a simple sequential execution of the program, CreatePCSample is executed each time the PE
// executes an instruction that can be sampled. An implementation is not constrained such that
// reads of EDPCSRlo return the current values of PC, etc.

pc_sample.valid = ExternalNoninvasiveDebugAllowed() && !Halted();
pc_sample.pc = ThisInstrAddr();
pc_sample.el = PSTATE.EL;
pc_sample.rw = if UsingAArch32() then '0' else '1';
pc_sample.ns = if IsSecure() then '0' else '1';
pc_sample.contextidr = if ELUsingAArch32(EL1) then CONTEXTIDR else CONTEXTIDR_EL1<31:0>;
pc_sample.has_el2 = EL2Enabled();

if EL2Enabled() then
    if ELUsingAArch32(EL2) then
        pc_sample.vmid = ZeroExtend(VTTBR.VMID, 16);
    elsif !Have16bitVMID() || VTCR_EL2.VS == '0' then
        pc_sample.vmid = ZeroExtend(VTTBR_EL2.VMID<7:0>, 16);
    else
        pc_sample.vmid = VTTBR_EL2.VMID;
    if (HaveVirtHostExt() || HaveV82Debug()) && !ELUsingAArch32(EL2) then
        pc_sample.contextidr_el2 = CONTEXTIDR_EL2<31:0>;
    else
        pc_sample.contextidr_el2 = bits(32) UNKNOWN;
    pc_sample.el0h = PSTATE.EL == EL0 && IsInHost();
return;
```



## Library pseudocode for shared/debug/samplebasedprofiling/EDPCSRlo

```
// EDPCSRlo[] (read)
// =====

bits(32) EDPCSRlo[boolean memory_mapped]

if EDPRSR<6:5,0> != '001' then // Check DLK, OSLK and PU bits
    IMPLEMENTATION_DEFINED "generate error response";
    return bits(32) UNKNOWN;

// The Software lock is OPTIONAL.
update = !memory_mapped || EDLSR.SLK == '0'; // Software locked: no side-effects

if pc_sample.valid then
    sample = pc_sample.pc<31:0>;
    if update then
        if HaveVirtHostExt() && EDSCR.SC2 == '1' then
            EDPCRhi.PC = (if pc_sample.rw == '0' then Zeros(24) else pc_sample.pc<55:32>);
            EDPCRhi.EL = pc_sample.el;
            EDPCRhi.NS = pc_sample.ns;
        else
            EDPCRhi = (if pc_sample.rw == '0' then Zeros(32) else pc_sample.pc<63:32>);
            EDCIDSR = pc_sample.contextidr;
            if (HaveVirtHostExt() || HaveV82Debug()) && EDSCR.SC2 == '1' then
                EDVIDSR = (if HaveEL(EL2) && pc_sample.ns == '1' then pc_sample.contextidr_el2
                    else bits(32) UNKNOWN);
            else
                if HaveEL(EL2) && pc_sample.ns == '1' && pc_sample.el IN {EL1,EL0} then
                    EDVIDSR.VMID = pc_sample.vmid;
                else
                    EDVIDSR.VMID = Zeros();
                    EDVIDSR.NS = pc_sample.ns;
                    EDVIDSR.E2 = (if pc_sample.el == EL2 then '1' else '0');
                    EDVIDSR.E3 = (if pc_sample.el == EL3 then '1' else '0') AND pc_sample.rw;
                    // The conditions for setting HV are not specified if PCSRhi is zero.
                    // An example implementation may be "pc_sample.rw".
                    EDVIDSR.HV = (if !IsZero(EDPCRhi) then '1' else bit IMPLEMENTATION_DEFINED "0 or 1");
        else
            sample = Ones(32);
            if update then
                EDPCRhi = bits(32) UNKNOWN;
                EDCIDSR = bits(32) UNKNOWN;
                EDVIDSR = bits(32) UNKNOWN;

    return sample;
```

## Library pseudocode for shared/debug/samplebasedprofiling/PCSample

```
type PCSample is (
    boolean valid,
    bits(64) pc,
    bits(2) el,
    bit rw,
    bit ns,
    boolean has_el2,
    bits(32) contextidr,
    bits(32) contextidr_el2,
    boolean el0h,
    bits(16) vmid
)

PCSample pc_sample;
```

## Library pseudocode for shared/debug/samplebasedprofiling/PMPCSR

```
// PMPCSR[] (read)
// =====

bits(32) PMPCSR[boolean memory_mapped]

    if EDPRSR<6:5,0> != '001' then // Check DLK, OSLK and PU bits
        IMPLEMENTATION_DEFINED "generate error response";
        return bits(32) UNKNOWN;

    // The Software lock is OPTIONAL.
    update = !memory_mapped || PMLSR.SLK == '0'; // Software locked: no side-effects

    if pc_sample.valid then
        sample = pc_sample.pc<31:0>;
        if update then
            PMPCSR<55:32> = (if pc_sample.rw == '0' then Zeros(24) else pc_sample.pc<55:32>);
            PMPCSR.EL = pc_sample.el;
            PMPCSR.NS = pc_sample.ns;

            PMCID1SR = pc_sample.contextidr;
            PMCID2SR = if pc_sample.has_el2 then pc_sample.contextidr_el2 else bits(32) UNKNOWN;

            PMVIDSR.VMID = (if pc_sample.has_el2 && pc_sample.el IN {EL1,EL0} && !pc_sample.el0h
                            then pc_sample.vmid else bits(16) UNKNOWN);
        else
            sample = Ones(32);
            if update then
                PMPCSR<55:32> = bits(24) UNKNOWN;
                PMPCSR.EL = bits(2) UNKNOWN;
                PMPCSR.NS = bit UNKNOWN;

                PMCID1SR = bits(32) UNKNOWN;
                PMCID2SR = bits(32) UNKNOWN;

                PMVIDSR.VMID = bits(16) UNKNOWN;

    return sample;
```

## Library pseudocode for shared/debug/softwarestep/CheckSoftwareStep

```
// CheckSoftwareStep()
// =====
// Take a Software Step exception if in the active-pending state

CheckSoftwareStep()

    // Other self-hosted debug functions will call AArch32.GenerateDebugExceptions() if called from
    // AArch32 state. However, because Software Step is only active when the debug target Exception
    // level is using AArch64, CheckSoftwareStep only calls AArch64.GenerateDebugExceptions().
    step_enabled = !ELUsingAArch32\(DebugTarget\(\)\) && AArch64.GenerateDebugExceptions\(\) && MDSCR_EL1.SS ==
    if step_enabled && PSTATE.SS == '0' then
        AArch64.SoftwareStepException\(\);
```

## Library pseudocode for shared/debug/softwarestep/DebugExceptionReturnSS

```
// DebugExceptionReturnSS()
// =====
// Returns value to write to PSTATE.SS on an exception return or Debug state exit.

bit DebugExceptionReturnSS(bits(N) spsr)
    if UsingAArch32() then
        assert N == 32;
    else
        assert N == 64;

    assert Halted() || Restarting() || PSTATE.EL != EL0;

    if Restarting() then
        enabled_at_source = FALSE;
    elsif UsingAArch32() then
        enabled_at_source = AArch32.GenerateDebugExceptions();
    else
        enabled_at_source = AArch64.GenerateDebugExceptions();

    if IllegalExceptionReturn(spsr) then
        dest = PSTATE.EL;
    else
        (valid, dest) = ELFromSPSR(spsr); assert valid;

    dest_is_secure = IsSecureBelowEL3() || dest == EL3;
    dest_using_32 = (if dest == EL0 then spsr<4> == '1' else ELUsingAArch32(dest));
    if dest_using_32 then
        enabled_at_dest = AArch32.GenerateDebugExceptionsFrom(dest, dest_is_secure);
    else
        mask = spsr<9>;
        enabled_at_dest = AArch64.GenerateDebugExceptionsFrom(dest, dest_is_secure, mask);

    ELd = DebugTargetFrom(dest_is_secure);
    if !ELUsingAArch32(ELd) && MDSCR_EL1.SS == '1' && !enabled_at_source && enabled_at_dest then
        SS_bit = spsr<21>;
    else
        SS_bit = '0';

    return SS_bit;
```

## Library pseudocode for shared/debug/softwarestep/SSAdvance

```
// SSAdvance()
// =====
// Advance the Software Step state machine.

SSAdvance()

    // A simpler implementation of this function just clears PSTATE.SS to zero regardless of the
    // current Software Step state machine. However, this check is made to illustrate that the
    // processor only needs to consider advancing the state machine from the active-not-pending
    // state.
    target = DebugTarget();
    step_enabled = !ELUsingAArch32(target) && MDSCR_EL1.SS == '1';
    active_not_pending = step_enabled && PSTATE.SS == '1';

    if active_not_pending then PSTATE.SS = '0';

    return;
```

## Library pseudocode for shared/debug/softwarestep/SoftwareStep\_DidNotStep

```
// Returns TRUE if the previously executed instruction was executed in the inactive state, that is,  
// if it was not itself stepped.  
// Might return TRUE or FALSE if the previously executed instruction was an ISB or ERET executed  
// in the active-not-pending state, or if another exception was taken before the Software Step exception.  
// Returns FALSE otherwise, indicating that the previously executed instruction was executed in the  
// active-not-pending state, that is, the instruction was stepped.  
boolean SoftwareStep_DidNotStep();
```

## Library pseudocode for shared/debug/softwarestep/SoftwareStep\_SteppedEX

```
// Returns a value that describes the previously executed instruction. The result is valid only if  
// SoftwareStep_DidNotStep() returns FALSE.  
// Might return TRUE or FALSE if the instruction was an AArch32 LDREX or LDAEX that failed its condition  
// Otherwise returns TRUE if the instruction was a Load-Exclusive class instruction, and FALSE if the  
// instruction was not a Load-Exclusive class instruction.  
boolean SoftwareStep_SteppedEX();
```

## Library pseudocode for shared/exceptions/exceptions/ConditionSyndrome

```
// ConditionSyndrome()  
// =====  
// Return CV and COND fields of instruction syndrome  
  
bits(5) ConditionSyndrome()  
  
    bits(5) syndrome;  
  
    if UsingAArch32() then  
        cond = AArch32.CurrentCond();  
        if PSTATE.T == '0' then // A32  
            syndrome<4> = '1';  
            // A conditional A32 instruction that is known to pass its condition code check  
            // can be presented either with COND set to 0xE, the value for unconditional, or  
            // the COND value held in the instruction.  
            if ConditionHolds(cond) && ConstrainUnpredictableBool(Unpredictable_ESRCONDPASS) then  
                syndrome<3:0> = '1110';  
            else  
                syndrome<3:0> = cond;  
        else // T32  
            // When a T32 instruction is trapped, it is IMPLEMENTATION DEFINED whether:  
            // * CV set to 0 and COND is set to an UNKNOWN value  
            // * CV set to 1 and COND is set to the condition code for the condition that  
            // applied to the instruction.  
            if boolean IMPLEMENTATION_DEFINED "Condition valid for trapped T32" then  
                syndrome<4> = '1';  
                syndrome<3:0> = cond;  
            else  
                syndrome<4> = '0';  
                syndrome<3:0> = bits(4) UNKNOWN;  
    else  
        syndrome<4> = '1';  
        syndrome<3:0> = '1110';  
  
    return syndrome;
```

## Library pseudocode for shared/exceptions/exceptions/Exception

```
enumeration Exception {Exception_Uncategorized,    // Uncategorized or unknown reason
                        Exception_WFxTrap,          // Trapped WFI or WFE instruction
                        Exception_CP15RTTTrap,      // Trapped AArch32 MCR or MRC access to CP15
                        Exception_CP15RRTTrap,      // Trapped AArch32 MCRR or MRRC access to CP15
                        Exception_CP14RTTTrap,      // Trapped AArch32 MCR or MRC access to CP14
                        Exception_CP14DTTTrap,      // Trapped AArch32 LDC or STC access to CP14
                        Exception_AdvSIMDFPAccessTrap, // HCPTR-trapped access to SIMD or FP
                        Exception_FPIDTrap,         // Trapped access to SIMD or FP ID register
                        Exception_LDST64BTrap,      // Trapped access to ST64BV, ST64BV0, ST64B and LDC
                        // Trapped BXJ instruction not supported in Armv8
                        Exception_PACTrap,          // Trapped invalid PAC use
                        Exception_CP14RRTTrap,      // Trapped MRRC access to CP14 from AArch32
                        Exception_IllegalState,     // Illegal Execution state
                        Exception_SupervisorCall,   // Supervisor Call
                        Exception_HypervisorCall,   // Hypervisor Call
                        Exception_MonitorCall,      // Monitor Call or Trapped SMC instruction
                        Exception_SystemRegisterTrap, // Trapped MRS or MSR system register access
                        Exception_ERetTrap,         // Trapped invalid ERET use
                        Exception_InstructionAbort,  // Instruction Abort or Prefetch Abort
                        Exception_PCAalignment,      // PC alignment fault
                        Exception_DataAbort,        // Data Abort
                        Exception_NV2DataAbort,     // Data abort at EL1 reported as being from EL2
                        Exception_PACFail,          // PAC Authentication failure
                        Exception_SPAlignment,      // SP alignment fault
                        Exception_FPTrappedException, // IEEE trapped FP exception
                        Exception_SError,           // SError interrupt
                        Exception_Breakpoint,       // (Hardware) Breakpoint
                        Exception_SoftwareStep,     // Software Step
                        Exception_Watchpoint,       // Watchpoint
                        Exception_NV2Watchpoint,    // Watchpoint at EL1 reported as being from EL2
                        Exception_SoftwareBreakpoint, // Software Breakpoint Instruction
                        Exception_VectorCatch,      // AArch32 Vector Catch
                        Exception_IRQ,              // IRQ interrupt
                        Exception_SVEAccessTrap,    // HCPTR trapped access to SVE
                        Exception_BranchTarget,     // Branch Target Identification
                        Exception_FIQ};             // FIQ interrupt
```

## Library pseudocode for shared/exceptions/exceptions/ExceptionRecord

```
type ExceptionRecord is (
    Exception    exceptype, // Exception class
    bits(25)    syndrome,   // Syndrome record
    bits(5)     syndrome2,  // ST64BV(0) return value register specifier
    bits(64)    vaddress,   // Virtual fault address
    boolean     ipavalid,   // Validity of Intermediate Physical fault address
    bit         NS,         // Intermediate Physical fault address space
    bits(52)    ipaddress) // Intermediate Physical fault address
```

## Library pseudocode for shared/exceptions/exceptions/ExceptionSyndrome

```
// ExceptionSyndrome()
// =====
// Return a blank exception syndrome record for an exception of the given type.

ExceptionRecord ExceptionSyndrome(Exception exceptype)

    ExceptionRecord r;

    r.exceptype = exceptype;

    // Initialize all other fields
    r.syndrome = Zeros();
    r.syndrome2 = Zeros();
    r.vaddress = Zeros();
    r.ipavalid = FALSE;
    r.NS = '0';
    r.ipaddress = Zeros();
    return r;
```

## Library pseudocode for shared/functions/aborts/EncodeLDFSC

```
// EncodeLDFSC()
// =====
// Function that gives the Long-descriptor FSC code for types of Fault

bits(6) EncodeLDFSC(Fault statuscode, integer level)
    bits(6) result;

    if level == -1 then
        assert Have52BitIPAAAndPASpaceExt();
        case statuscode of
            when Fault_AddressSize          result = '101001';
            when Fault_Translation           result = '101011';
            when Fault_SyncExternalOnWalk    result = '010011';
            when Fault_SyncParityOnWalk      result = '011011'; assert !HaveRASExt();
            otherwise                        Unreachable();

        return result;
    case statuscode of
        when Fault_AddressSize          result = '0000':level<1:0>; assert level IN {0,1,2,3};
        when Fault_AccessFlag           result = '0010':level<1:0>; assert level IN {0,1,2,3};
        when Fault_Permission           result = '0011':level<1:0>; assert level IN {0,1,2,3};
        when Fault_Translation           result = '0001':level<1:0>; assert level IN {0,1,2,3};
        when Fault_SyncExternal          result = '010000';
        when Fault_SyncExternalOnWalk    result = '0101':level<1:0>; assert level IN {0,1,2,3};
        when Fault_SyncParity            result = '011000';
        when Fault_SyncParityOnWalk      result = '0111':level<1:0>; assert level IN {0,1,2,3};
        when Fault_AsyncParity           result = '011001';
        when Fault_AsyncExternal         result = '010001';
        when Fault_Alignment             result = '100001';
        when Fault_Debug                 result = '100010';
        when Fault_TLBConflict           result = '110000';
        when Fault_HWUpdateAccessFlag    result = '110001';
        when Fault_Lockdown              result = '110100'; // IMPLEMENTATION DEFINED
        when Fault_Exclusive             result = '110101'; // IMPLEMENTATION DEFINED
        otherwise                        Unreachable();

    return result;
```

## Library pseudocode for shared/functions/aborts/IPAValid

```
// IPAValid()
// =====
// Return TRUE if the IPA is reported for the abort

boolean IPAValid(FaultRecord fault)
    assert fault.statuscode != Fault\_None;

    if fault.s2fslwalk then
        return fault.statuscode IN {
            Fault\_AccessFlag,
            Fault\_Permission,
            Fault\_Translation,
            Fault\_AddressSize
        };
    elsif fault.secondstage then
        return fault.statuscode IN {
            Fault\_AccessFlag,
            Fault\_Translation,
            Fault\_AddressSize
        };
    else
        return FALSE;
```

## Library pseudocode for shared/functions/aborts/IsAsyncAbort

```
// IsAsyncAbort()
// =====
// Returns TRUE if the abort currently being processed is an asynchronous abort, and FALSE
// otherwise.

boolean IsAsyncAbort(Fault statuscode)
    assert statuscode != Fault\_None;

    return (statuscode IN {Fault\_AsyncExternal, Fault\_AsyncParity});

// IsAsyncAbort()
// =====

boolean IsAsyncAbort(FaultRecord fault)
    return IsAsyncAbort(fault.statuscode);
```

## Library pseudocode for shared/functions/aborts/IsDebugException

```
// IsDebugException()
// =====

boolean IsDebugException(FaultRecord fault)
    assert fault.statuscode != Fault\_None;
    return fault.statuscode == Fault\_Debug;
```

### Library pseudocode for shared/functions/aborts/IsExternalAbort

```
// IsExternalAbort()
// =====
// Returns TRUE if the abort currently being processed is an External abort and FALSE otherwise.

boolean IsExternalAbort(Fault statuscode)
    assert statuscode != Fault_None;

    return (statuscode IN {
        Fault_SyncExternal,
        Fault_SyncParity,
        Fault_SyncExternalOnWalk,
        Fault_SyncParityOnWalk,
        Fault_AsyncExternal,
        Fault_AsyncParity
    });

// IsExternalAbort()
// =====

boolean IsExternalAbort(FaultRecord fault)
    return IsExternalAbort(fault.statuscode);
```

### Library pseudocode for shared/functions/aborts/IsExternalSyncAbort

```
// IsExternalSyncAbort()
// =====
// Returns TRUE if the abort currently being processed is an external synchronous abort and FALSE otherwise.

boolean IsExternalSyncAbort(Fault statuscode)
    assert statuscode != Fault_None;

    return (statuscode IN {
        Fault_SyncExternal,
        Fault_SyncParity,
        Fault_SyncExternalOnWalk,
        Fault_SyncParityOnWalk
    });

// IsExternalSyncAbort()
// =====

boolean IsExternalSyncAbort(FaultRecord fault)
    return IsExternalSyncAbort(fault.statuscode);
```

### Library pseudocode for shared/functions/aborts/IsFault

```
// IsFault()
// =====
// Return TRUE if a fault is associated with an address descriptor

boolean IsFault(AddressDescriptor addrdesc)
    return addrdesc.fault.statuscode != Fault_None;
```



### Library pseudocode for shared/functions/aborts/IsSErrorInterrupt

```
// IsSErrorInterrupt()
// =====
// Returns TRUE if the abort currently being processed is an SError interrupt, and FALSE
// otherwise.

boolean IsSErrorInterrupt(Fault statuscode)
    assert statuscode != Fault_None;

    return (statuscode IN {Fault_AsyncExternal, Fault_AsyncParity});

// IsSErrorInterrupt()
// =====

boolean IsSErrorInterrupt(FaultRecord fault)
    return IsSErrorInterrupt(fault.statuscode);
```

### Library pseudocode for shared/functions/aborts/IsSecondStage

```
// IsSecondStage()
// =====

boolean IsSecondStage(FaultRecord fault)
    assert fault.statuscode != Fault_None;

    return fault.secondstage;
```

### Library pseudocode for shared/functions/aborts/LSInstructionSyndrome

```
// Returns the extended syndrome information for a second stage fault.
// <10> - Syndrome valid bit. The syndrome is only valid for certain types of access instruction.
// <9:8> - Access size.
// <7> - Sign extended (for loads).
// <6:2> - Transfer register.
// <1> - Transfer register is 64-bit.
// <0> - Instruction has acquire/release semantics.
bits(11) LSInstructionSyndrome();
```

### Library pseudocode for shared/functions/common/ASR

```
// ASR()
// =====

bits(N) ASR(bits(N) x, integer shift)
    assert shift >= 0;
    if shift == 0 then
        result = x;
    else
        (result, -) = ASR_C(x, shift);
    return result;
```

### Library pseudocode for shared/functions/common/ASR\_C

```
// ASR_C()
// =====

(bits(N), bit) ASR_C(bits(N) x, integer shift)
    assert shift > 0;
    extended_x = SignExtend(x, shift+N);
    result = extended_x<shift+N-1:shift>;
    carry_out = extended_x<shift-1>;
    return (result, carry_out);
```

### Library pseudocode for shared/functions/common/Abs

```
// Abs()
// =====

integer Abs(integer x)
    return if x >= 0 then x else -x;

// Abs()
// =====

real Abs(real x)
    return if x >= 0.0 then x else -x;
```

### Library pseudocode for shared/functions/common/Align

```
// Align()
// =====

integer Align(integer x, integer y)
    return y * (x DIV y);

// Align()
// =====

bits(N) Align(bits(N) x, integer y)
    return Align(UInt(x), y)<N-1:0>;
```

### Library pseudocode for shared/functions/common/BitCount

```
// BitCount()
// =====

integer BitCount(bits(N) x)
    integer result = 0;
    for i = 0 to N-1
        if x<i> == '1' then
            result = result + 1;
    return result;
```

### Library pseudocode for shared/functions/common/CountLeadingSignBits

```
// CountLeadingSignBits()
// =====

integer CountLeadingSignBits(bits(N) x)
    return CountLeadingZeroBits(x<N-1:1> EOR x<N-2:0>);
```

### Library pseudocode for shared/functions/common/CountLeadingZeroBits

```
// CountLeadingZeroBits()
// =====

integer CountLeadingZeroBits(bits(N) x)
    return N - (HighestSetBit(x) + 1);
```

## Library pseudocode for shared/functions/common/Elem

```
// Elem[] - non-assignment form
// =====

bits(size) Elem(bits(N) vector, integer e, integer size]
    assert e >= 0 && (e+1)*size <= N;
    return vector<e*size+size-1 : e*size>;

// Elem[] - non-assignment form
// =====

bits(size) Elem(bits(N) vector, integer e]
    return Elem[vector, e, size];

// Elem[] - assignment form
// =====

Elem(bits(N) &vector, integer e, integer size] = bits(size) value
    assert e >= 0 && (e+1)*size <= N;
    vector<(e+1)*size-1:e*size> = value;
    return;

// Elem[] - assignment form
// =====

Elem(bits(N) &vector, integer e] = bits(size) value
    Elem[vector, e, size] = value;
    return;
```

## Library pseudocode for shared/functions/common/Extend

```
// Extend()
// =====

bits(N) Extend(bits(M) x, integer N, boolean unsigned)
    return if unsigned then ZeroExtend(x, N) else SignExtend(x, N);

// Extend()
// =====

bits(N) Extend(bits(M) x, boolean unsigned)
    return Extend(x, N, unsigned);
```

## Library pseudocode for shared/functions/common/HighestSetBit

```
// HighestSetBit()
// =====

integer HighestSetBit(bits(N) x)
    for i = N-1 downto 0
        if x<i> == '1' then return i;
    return -1;
```

## Library pseudocode for shared/functions/common/Int

```
// Int()
// =====

integer Int(bits(N) x, boolean unsigned)
    result = if unsigned then UInt(x) else SInt(x);
    return result;
```

### Library pseudocode for shared/functions/common/IsOnes

```
// IsOnes()
// =====

boolean IsOnes(bits(N) x)
    return x == Ones(N);
```

### Library pseudocode for shared/functions/common/IsZero

```
// IsZero()
// =====

boolean IsZero(bits(N) x)
    return x == Zeros(N);
```

### Library pseudocode for shared/functions/common/IsZeroBit

```
// IsZeroBit()
// =====

bit IsZeroBit(bits(N) x)
    return if IsZero(x) then '1' else '0';
```

### Library pseudocode for shared/functions/common/LSL

```
// LSL()
// =====

bits(N) LSL(bits(N) x, integer shift)
    assert shift >= 0;
    if shift == 0 then
        result = x;
    else
        (result, -) = LSL\_C(x, shift);
    return result;
```

### Library pseudocode for shared/functions/common/LSL\_C

```
// LSL_C()
// =====

(bits(N), bit) LSL_C(bits(N) x, integer shift)
    assert shift > 0;
    extended_x = x : Zeros(shift);
    result = extended_x<N-1:0>;
    carry_out = extended_x<N>;
    return (result, carry_out);
```

### Library pseudocode for shared/functions/common/LSR

```
// LSR()
// =====

bits(N) LSR(bits(N) x, integer shift)
    assert shift >= 0;
    if shift == 0 then
        result = x;
    else
        (result, -) = LSR\_C(x, shift);
    return result;
```

### Library pseudocode for shared/functions/common/LSR\_C

```
// LSR_C()
// =====

(bits(N), bit) LSR_C(bits(N) x, integer shift)
  assert shift > 0;
  extended_x = ZeroExtend(x, shift+N);
  result = extended_x<shift+N-1:shift>;
  carry_out = extended_x<shift-1>;
  return (result, carry_out);
```

### Library pseudocode for shared/functions/common/LowestSetBit

```
// LowestSetBit()
// =====

integer LowestSetBit(bits(N) x)
  for i = 0 to N-1
    if x<i> == '1' then return i;
  return N;
```

### Library pseudocode for shared/functions/common/Max

```
// Max()
// =====

integer Max(integer a, integer b)
  return if a >= b then a else b;

// Max()
// =====

real Max(real a, real b)
  return if a >= b then a else b;
```

### Library pseudocode for shared/functions/common/Min

```
// Min()
// =====

integer Min(integer a, integer b)
  return if a <= b then a else b;

// Min()
// =====

real Min(real a, real b)
  return if a <= b then a else b;
```

### Library pseudocode for shared/functions/common/Ones

```
// Ones()
// =====

bits(N) Ones(integer N)
  return Replicate('1',N);

// Ones()
// =====

bits(N) Ones()
  return Ones(N);
```

### Library pseudocode for shared/functions/common/ROR

```
// ROR()
// =====

bits(N) ROR(bits(N) x, integer shift)
    assert shift >= 0;
    if shift == 0 then
        result = x;
    else
        (result, -) = ROR_C(x, shift);
    return result;
```

### Library pseudocode for shared/functions/common/ROR\_C

```
// ROR_C()
// =====

(bits(N), bit) ROR_C(bits(N) x, integer shift)
    assert shift != 0;
    m = shift MOD N;
    result = LSR(x,m) OR LSL(x,N-m);
    carry_out = result<N-1>;
    return (result, carry_out);
```

### Library pseudocode for shared/functions/common/Replicate

```
// Replicate()
// =====

bits(N) Replicate(bits(M) x)
    assert N MOD M == 0;
    return Replicate(x, N DIV M);

bits(M*N) Replicate(bits(M) x, integer N);
```

### Library pseudocode for shared/functions/common/RoundDown

```
integer RoundDown(real x);
```

### Library pseudocode for shared/functions/common/RoundTowardsZero

```
// RoundTowardsZero()
// =====

integer RoundTowardsZero(real x)
    return if x == 0.0 then 0 else if x >= 0.0 then RoundDown(x) else RoundUp(x);
```

### Library pseudocode for shared/functions/common/RoundUp

```
integer RoundUp(real x);
```

### Library pseudocode for shared/functions/common/SInt

```
// SInt()
// =====

integer SInt(bits(N) x)
    result = 0;
    for i = 0 to N-1
        if x<i> == '1' then result = result + 2^i;
    if x<N-1> == '1' then result = result - 2^N;
    return result;
```

### Library pseudocode for shared/functions/common/SignExtend

```
// SignExtend()
// =====

bits(N) SignExtend(bits(M) x, integer N)
    assert N >= M;
    return Replicate(x<M-1>, N-M) : x;

// SignExtend()
// =====

bits(N) SignExtend(bits(M) x)
    return SignExtend(x, N);
```

### Library pseudocode for shared/functions/common/UInt

```
// UInt()
// =====

integer UInt(bits(N) x)
    result = 0;
    for i = 0 to N-1
        if x<i> == '1' then result = result + 2^i;
    return result;
```

### Library pseudocode for shared/functions/common/ZeroExtend

```
// ZeroExtend()
// =====

bits(N) ZeroExtend(bits(M) x, integer N)
    assert N >= M;
    return Zeros(N-M) : x;

// ZeroExtend()
// =====

bits(N) ZeroExtend(bits(M) x)
    return ZeroExtend(x, N);
```

### Library pseudocode for shared/functions/common/Zeros

```
// Zeros()
// =====

bits(N) Zeros(integer N)
    return Replicate('0',N);

// Zeros()
// =====

bits(N) Zeros()
    return Zeros(N);
```

### Library pseudocode for shared/functions/crc/BitReverse

```
// BitReverse()
// =====

bits(N) BitReverse(bits(N) data)
    bits(N) result;
    for i = 0 to N-1
        result<N-i-1> = data<i>;
    return result;
```

## Library pseudocode for shared/functions/crc/HaveCRCExt

```
// HaveCRCExt()  
// =====  
  
boolean HaveCRCExt()  
    return HasArchVersion\(ARMv8p1\) || boolean IMPLEMENTATION_DEFINED "Have CRC extension";
```

## Library pseudocode for shared/functions/crc/Poly32Mod2

```
// Poly32Mod2()  
// =====  
  
// Poly32Mod2 on a bitstring does a polynomial Modulus over {0,1} operation  
  
bits(32) Poly32Mod2(bits(N) data, bits(32) poly)  
    assert N > 32;  
    for i = N-1 downto 32  
        if data<i> == '1' then  
            data<i-1:0> = data<i-1:0> EOR (poly:Zeros(i-32));  
    return data<31:0>;
```

## Library pseudocode for shared/functions/crypto/AESInvMixColumns

```
// AESInvMixColumns()  
// =====  
// Transformation in the Inverse Cipher that is the inverse of AESMixColumns.  
  
bits(128) AESInvMixColumns(bits (128) op)  
    bits(4*8) in0 = op< 96+:8> : op< 64+:8> : op< 32+:8> : op<  0+:8>;  
    bits(4*8) in1 = op<104+:8> : op< 72+:8> : op< 40+:8> : op<  8+:8>;  
    bits(4*8) in2 = op<112+:8> : op< 80+:8> : op< 48+:8> : op< 16+:8>;  
    bits(4*8) in3 = op<120+:8> : op< 88+:8> : op< 56+:8> : op< 24+:8>;  
  
    bits(4*8) out0;  
    bits(4*8) out1;  
    bits(4*8) out2;  
    bits(4*8) out3;  
  
    for c = 0 to 3  
        out0<c*8+:8> = FFmul0E(in0<c*8+:8>) EOR FFmul0B(in1<c*8+:8>) EOR FFmul0D(in2<c*8+:8>) EOR FFmul09(in3<c*8+:8>);  
        out1<c*8+:8> = FFmul09(in0<c*8+:8>) EOR FFmul0E(in1<c*8+:8>) EOR FFmul0B(in2<c*8+:8>) EOR FFmul0D(in3<c*8+:8>);  
        out2<c*8+:8> = FFmul0D(in0<c*8+:8>) EOR FFmul09(in1<c*8+:8>) EOR FFmul0E(in2<c*8+:8>) EOR FFmul0B(in3<c*8+:8>);  
        out3<c*8+:8> = FFmul0B(in0<c*8+:8>) EOR FFmul0D(in1<c*8+:8>) EOR FFmul09(in2<c*8+:8>) EOR FFmul0E(in3<c*8+:8>);  
  
    return (  
        out3<3*8+:8> : out2<3*8+:8> : out1<3*8+:8> : out0<3*8+:8> :  
        out3<2*8+:8> : out2<2*8+:8> : out1<2*8+:8> : out0<2*8+:8> :  
        out3<1*8+:8> : out2<1*8+:8> : out1<1*8+:8> : out0<1*8+:8> :  
        out3<0*8+:8> : out2<0*8+:8> : out1<0*8+:8> : out0<0*8+:8>  
    );
```

## Library pseudocode for shared/functions/crypto/AESInvShiftRows

```
// AESInvShiftRows()  
// =====  
// Transformation in the Inverse Cipher that is inverse of AESShiftRows.  
  
bits(128) AESInvShiftRows(bits(128) op)  
    return (  
        op< 24+:8> : op< 48+:8> : op< 72+:8> : op< 96+:8> :  
        op<120+:8> : op< 16+:8> : op< 40+:8> : op< 64+:8> :  
        op< 88+:8> : op<112+:8> : op<  8+:8> : op< 32+:8> :  
        op< 56+:8> : op< 80+:8> : op<104+:8> : op<  0+:8>  
    );
```



## Library pseudocode for shared/functions/crypto/AESInvSubBytes

```
// AESInvSubBytes()
// =====
// Transformation in the Inverse Cipher that is the inverse of AESSubBytes.

bits(128) AESInvSubBytes(bits(128) op)
  // Inverse S-box values
  bits(16*16*8) GF2_inv = (
    /*      F E D C B A 9 8 7 6 5 4 3 2 1 0      */
    /*F*/ 0x7d0c2155631469e126d677ba7e042b17<127:0> :
    /*E*/ 0x619953833cbbbec8b0f52aae4d3be0a0<127:0> :
    /*D*/ 0xef9cc9939f7ae52d0d4ab519a97f5160<127:0> :
    /*C*/ 0x5fec8027591012b131c7078833a8dd1f<127:0> :
    /*B*/ 0xf45acd78fec0db9a2079d2c64b3e56fc<127:0> :
    /*A*/ 0x1bbe18aa0e62b76f89c5291d711af147<127:0> :
    /*9*/ 0x6edf751ce837f9e28535ade72274ac96<127:0> :
    /*8*/ 0x73e6b4f0cecff297eadc674f4111913a<127:0> :
    /*7*/ 0x6b8a130103bdafc1020f3fca8f1e2cd0<127:0> :
    /*6*/ 0x0645b3b80558e4f70ad3bc8c00abd890<127:0> :
    /*5*/ 0x849d8da75746155edab9edfd5048706c<127:0> :
    /*4*/ 0x92b6655dcc5ca4d41698688664f6f872<127:0> :
    /*3*/ 0x25d18b6d49a25b76b224d92866a12e08<127:0> :
    /*2*/ 0x4ec3fa420b954cee3d23c2a632947b54<127:0> :
    /*1*/ 0xcbe9dec444438e3487ff2f9b8239e37c<127:0> :
    /*0*/ 0xfbd7f3819ea340bf38a53630d56a0952<127:0>
  );
  bits(128) out;
  for i = 0 to 15
    out<i*8+:8> = GF2_inv<UInt(op<i*8+:8>)*8+:8>;
  return out;
```

## Library pseudocode for shared/functions/crypto/AESMixColumns

```
// AESMixColumns()
// =====
// Transformation in the Cipher that takes all of the columns of the
// State and mixes their data (independently of one another) to
// produce new columns.

bits(128) AESMixColumns(bits (128) op)
  bits(4*8) in0 = op< 96+:8> : op< 64+:8> : op< 32+:8> : op<  0+:8>;
  bits(4*8) in1 = op<104+:8> : op< 72+:8> : op< 40+:8> : op<  8+:8>;
  bits(4*8) in2 = op<112+:8> : op< 80+:8> : op< 48+:8> : op< 16+:8>;
  bits(4*8) in3 = op<120+:8> : op< 88+:8> : op< 56+:8> : op< 24+:8>;

  bits(4*8) out0;
  bits(4*8) out1;
  bits(4*8) out2;
  bits(4*8) out3;

  for c = 0 to 3
    out0<c*8+:8> = FFmul02(in0<c*8+:8>) EOR FFmul03(in1<c*8+:8>) EOR          in2<c*8+:8> EOR
    out1<c*8+:8> =          in0<c*8+:8> EOR FFmul02(in1<c*8+:8>) EOR FFmul03(in2<c*8+:8>) EOR
    out2<c*8+:8> =          in0<c*8+:8> EOR          in1<c*8+:8> EOR FFmul02(in2<c*8+:8>) EOR FFmul03(in3<c*8+:8>)
    out3<c*8+:8> = FFmul03(in0<c*8+:8>) EOR          in1<c*8+:8> EOR          in2<c*8+:8> EOR FFmul02(in3<c*8+:8>)

  return (
    out3<3*8+:8> : out2<3*8+:8> : out1<3*8+:8> : out0<3*8+:8> :
    out3<2*8+:8> : out2<2*8+:8> : out1<2*8+:8> : out0<2*8+:8> :
    out3<1*8+:8> : out2<1*8+:8> : out1<1*8+:8> : out0<1*8+:8> :
    out3<0*8+:8> : out2<0*8+:8> : out1<0*8+:8> : out0<0*8+:8>
  );
```

## Library pseudocode for shared/functions/crypto/AESShiftRows

```
// AESShiftRows()
// =====
// Transformation in the Cipher that processes the State by cyclically
// shifting the last three rows of the State by different offsets.

bits(128) AESShiftRows(bits(128) op)
    return (
        op< 88+:8> : op< 48+:8> : op<  8+:8> : op< 96+:8> :
        op< 56+:8> : op< 16+:8> : op<104+:8> : op< 64+:8> :
        op< 24+:8> : op<112+:8> : op< 72+:8> : op< 32+:8> :
        op<120+:8> : op< 80+:8> : op< 40+:8> : op<  0+:8>
    );
```

## Library pseudocode for shared/functions/crypto/AESSubBytes

```
// AESSubBytes()
// =====
// Transformation in the Cipher that processes the State using a nonlinear
// byte substitution table (S-box) that operates on each of the State bytes
// independently.

bits(128) AESSubBytes(bits(128) op)
    // S-box values
    bits(16*16*8) GF2 = (
        /*      F E D C B A 9 8 7 6 5 4 3 2 1 0      */
        /*F*/ 0x16bb54b00f2d99416842e6bf0d89a18c<127:0> :
        /*E*/ 0xdf2855cee9871e9b948ed9691198f8e1<127:0> :
        /*D*/ 0x9e1dc186b95735610ef6034866b53e70<127:0> :
        /*C*/ 0x8a8bbd4b1f74dde8c6b4a61c2e2578ba<127:0> :
        /*B*/ 0x08ae7a65eaf4566ca94ed58d6d37c8e7<127:0> :
        /*A*/ 0x79e4959162acd3c25c2406490a3a32e0<127:0> :
        /*9*/ 0xdb0b5ede14b8ee4688902a22dc4f8160<127:0> :
        /*8*/ 0x73195d643d7ea7c41744975fec130ccd<127:0> :
        /*7*/ 0xd2f3ff1021dab6bcf5389d928f40a351<127:0> :
        /*6*/ 0xa89f3c507f02f94585334d43fbaefd0<127:0> :
        /*5*/ 0xcf584c4a39becb6a5bb1fc20ed00d153<127:0> :
        /*4*/ 0x842fe329b3d63b52a05a6e1b1a2c8309<127:0> :
        /*3*/ 0x75b227ebe28012079a059618c323c704<127:0> :
        /*2*/ 0x1531d871f1e5a534ccf73f362693fdb7<127:0> :
        /*1*/ 0xc072a49cafa2d4adf04759fa7dc982ca<127:0> :
        /*0*/ 0x76abd7fe2b670130c56f6bf27b777c63<127:0>
    );
    bits(128) out;
    for i = 0 to 15
        out<i*8+:8> = GF2<UInt>(op<i*8+:8>)*8+:8>;
    return out;
```

## Library pseudocode for shared/functions/crypto/FFmul02

```
// FFmul02()
// =====

bits(8) FFmul02(bits(8) b)
  bits(256*8) FFmul_02 = (
    /*      F E D C B A 9 8 7 6 5 4 3 2 1 0      */
    /*F*/ 0xE5E7E1E3EDEFE9EBF5F7F1F3FDFFF9FB<127:0> :
    /*E*/ 0xC5C7C1C3CDCFC9CBD5D7D1D3DDDFD9DB<127:0> :
    /*D*/ 0xA5A7A1A3ADAF9ABB5B7B1B3BDBFB9BB<127:0> :
    /*C*/ 0x858781838D8F898B959791939D9F999B<127:0> :
    /*B*/ 0x656761636D6F696B757771737D7F797B<127:0> :
    /*A*/ 0x454741434D4F494B555751535D5F595B<127:0> :
    /*9*/ 0x252721232D2F292B353731333D3F393B<127:0> :
    /*8*/ 0x050701030D0F090B151711131D1F191B<127:0> :
    /*7*/ 0xFEFCFAF8F6F4F2F0EEECEAE8E6E4E2E0<127:0> :
    /*6*/ 0xDEDCDAD8D6D4D2D0CECCAC8C6C4C2C0<127:0> :
    /*5*/ 0xBEBBCBAB8B8B4B2B0AEACAAA8A6A4A2A0<127:0> :
    /*4*/ 0x9E9C9A98969492908E8C8A8886848280<127:0> :
    /*3*/ 0x7E7C7A78767472706E6C6A6866646260<127:0> :
    /*2*/ 0x5E5C5A58565452504E4C4A4846444240<127:0> :
    /*1*/ 0x3E3C3A38363432302E2C2A2826242220<127:0> :
    /*0*/ 0x1E1C1A18161412100E0C0A0806040200<127:0>
  );
  return FFmul_02<UInt(b)*8+:8>;
```

## Library pseudocode for shared/functions/crypto/FFmul03

```
// FFmul03()
// =====

bits(8) FFmul03(bits(8) b)
  bits(256*8) FFmul_03 = (
    /*      F E D C B A 9 8 7 6 5 4 3 2 1 0      */
    /*F*/ 0x1A191C1F16151013020104070E0D080B<127:0> :
    /*E*/ 0x2A292C2F26252023323134373E3D383B<127:0> :
    /*D*/ 0x7A797C7F76757073626164676E6D686B<127:0> :
    /*C*/ 0x4A494C4F46454043525154575E5D585B<127:0> :
    /*B*/ 0xDAD9DCDFD6D5D0D3C2C1C4C7CECDC8CB<127:0> :
    /*A*/ 0xEAE9ECEFE6E5E0E3F2F1F4F7FEFDF8FB<127:0> :
    /*9*/ 0xBAB9BCBFB6B5B0B3A2A1A4A7AEADA8AB<127:0> :
    /*8*/ 0x8A898C8F86858083929194979E9D989B<127:0> :
    /*7*/ 0x818287848D8E8B88999A9F9C95969390<127:0> :
    /*6*/ 0xB1B2B7B4BDBEBBB8A9AAAFACA5A6A3A0<127:0> :
    /*5*/ 0xE1E2E7E4EDEEEBE8F9FAFFFCF5F6F3F0<127:0> :
    /*4*/ 0xD1D2D7D4DDDEDBD8C9CACFCCC5C6C3C0<127:0> :
    /*3*/ 0x414247444D4E4B48595A5F5C55565350<127:0> :
    /*2*/ 0x717277747D7E7B78696A6F6C65666360<127:0> :
    /*1*/ 0x212227242D2E2B28393A3F3C35363330<127:0> :
    /*0*/ 0x111217141D1E1B18090A0F0C05060300<127:0>
  );
  return FFmul_03<UInt(b)*8+:8>;
```

## Library pseudocode for shared/functions/crypto/FFmul09

```
// FFmul09()
// =====

bits(8) FFmul09(bits(8) b)
    bits(256*8) FFmul_09 = (
        /*      F E D C B A 9 8 7 6 5 4 3 2 1 0      */
        /*F*/ 0x464F545D626B70790E071C152A233831<127:0> :
        /*E*/ 0xD6DFC4CDF2FBE0E99E978C85BAB3A8A1<127:0> :
        /*D*/ 0x7D746F6659504B42353C272E1118030A<127:0> :
        /*C*/ 0xEDE4FFF6C9C0DBD2A5ACB7BE8188939A<127:0> :
        /*B*/ 0x3039222B141D060F78716A635C554E47<127:0> :
        /*A*/ 0xA0A9B2BB848D969FE8E1FAF3CCC5DED7<127:0> :
        /*9*/ 0x0B0219102F263D34434A5158676E757C<127:0> :
        /*8*/ 0x9B928980BFB6ADA4D3DAC1C8F7FEE5EC<127:0> :
        /*7*/ 0xAAA3B8B18E879C95E2EBF0F9C6CFD4DD<127:0> :
        /*6*/ 0x3A3328211E170C05727B6069565F444D<127:0> :
        /*5*/ 0x9198838AB5BCA7AED9D0CBC2FDF4EFE6<127:0> :
        /*4*/ 0x0108131A252C373E49405B526D647F76<127:0> :
        /*3*/ 0xDCD5CEC7F8F1EAE3949D868FB0B9A2AB<127:0> :
        /*2*/ 0x4C455E5768617A73040D161F2029323B<127:0> :
        /*1*/ 0xE7EEF5FCC3CAD1D8AFA6BDB48B829990<127:0> :
        /*0*/ 0x777E656C535A41483F362D241B120900<127:0>
    );
    return FFmul_09<UInt(b)*8+:8>;
```

## Library pseudocode for shared/functions/crypto/FFmul0B

```
// FFmul0B()
// =====

bits(8) FFmul0B(bits(8) b)
    bits(256*8) FFmul_0B = (
        /*      F E D C B A 9 8 7 6 5 4 3 2 1 0      */
        /*F*/ 0xA3A8B5BE8F849992FBF0EDE6D7DCC1CA<127:0> :
        /*E*/ 0x1318050E3F3429224B405D56676C717A<127:0> :
        /*D*/ 0xD8D3CEC5F4FFE2E9808B969DACA7BAB1<127:0> :
        /*C*/ 0x68637E75444F5259303B262D1C170A01<127:0> :
        /*B*/ 0x555E434879726F640D061B10212A373C<127:0> :
        /*A*/ 0xE5EEF3F8C9C2DFD4BDB6ABA0919A878C<127:0> :
        /*9*/ 0x2E2538330209141F767D606B5A514C47<127:0> :
        /*8*/ 0x9E958883B2B9A4AFC6CDD0DBEAE1FCF7<127:0> :
        /*7*/ 0x545F424978736E650C071A11202B363D<127:0> :
        /*6*/ 0xE4EFF2F9C8C3DED5BCB7AAA1909B868D<127:0> :
        /*5*/ 0x2F2439320308151E777C616A5B504D46<127:0> :
        /*4*/ 0x9F948982B3B8A5AEC7CCD1DAEBE0FDF6<127:0> :
        /*3*/ 0xA2A9B4BF8E859893FAF1ECE7D6DDC0CB<127:0> :
        /*2*/ 0x1219040F3E3528234A415C57666D707B<127:0> :
        /*1*/ 0xD9D2CFC4F5FEE3E8818A979CADA6BBB0<127:0> :
        /*0*/ 0x69627F74454E5358313A272C1D160B00<127:0>
    );
    return FFmul_0B<UInt(b)*8+:8>;
```

## Library pseudocode for shared/functions/crypto/FFmul0D

```
// FFmul0D()
// =====

bits(8) FFmul0D(bits(8) b)
    bits(256*8) FFmul_0D = (
        /*      F E D C B A 9 8 7 6 5 4 3 2 1 0      */
        /*F*/ 0x979A8D80A3AEB9B4FFF2E5E8CBC6D1DC<127:0> :
        /*E*/ 0x474A5D50737E69642F2235381B16010C<127:0> :
        /*D*/ 0x2C21363B1815020F44495E53707D6A67<127:0> :
        /*C*/ 0xFCF1E6EBC8C5D2DF94998E83A0ADBAB7<127:0> :
        /*B*/ 0xFAF7E0EDCEC3D4D9929F8885A6ABBCB1<127:0> :
        /*A*/ 0x2A27303D1E130409424F5855767B6C61<127:0> :
        /*9*/ 0x414C5B5675786F622924333E1D10070A<127:0> :
        /*8*/ 0x919C8B86A5A8BFB2F9F4E3EECDC0D7DA<127:0> :
        /*7*/ 0x4D40575A7974636E25283F32111C0B06<127:0> :
        /*6*/ 0x9D90878AA9A4B3BEF5F8EFE2C1CCDBD6<127:0> :
        /*5*/ 0xF6FBCECE1C2CFD8D59E938489AAA7B0BD<127:0> :
        /*4*/ 0x262B3C31121F08054E4354597A77606D<127:0> :
        /*3*/ 0x202D3A3714190E034845525F7C71666B<127:0> :
        /*2*/ 0xF0FDEAE7C4C9DED39895828FACA1B6BB<127:0> :
        /*1*/ 0x9B96818CAFA2B5B8F3FEE9E4C7CADD00<127:0> :
        /*0*/ 0x4B46515C7F726568232E3934171A0D00<127:0>
    );
    return FFmul_0D<UInt(b)*8+:8>;
```

## Library pseudocode for shared/functions/crypto/FFmul0E

```
// FFmul0E()
// =====

bits(8) FFmul0E(bits(8) b)
    bits(256*8) FFmul_0E = (
        /*      F E D C B A 9 8 7 6 5 4 3 2 1 0      */
        /*F*/ 0x8D83919FB5BBA9A7FDF3E1EFC5CBD9D7<127:0> :
        /*E*/ 0x6D63717F555B49471D13010F252B3937<127:0> :
        /*D*/ 0x56584A446E60727C26283A341E10020C<127:0> :
        /*C*/ 0xB6B8AAA48E80929CC6C8DAD4FEF0E2EC<127:0> :
        /*B*/ 0x202E3C321816040A505E4C426866747A<127:0> :
        /*A*/ 0xC0CEDCD2F8F6E4EAB0BEACA28886949A<127:0> :
        /*9*/ 0xFBF5E7E9C3CDDFD18B859799B3BDFAFA1<127:0> :
        /*8*/ 0x1B150709232D3F316B657779535D4F41<127:0> :
        /*7*/ 0xCCC2D0DEF4FAE8E6BCB2A0AE848A9896<127:0> :
        /*6*/ 0x2C22303E141A08065C52404E646A7876<127:0> :
        /*5*/ 0x17190B052F21333D67697B755F51434D<127:0> :
        /*4*/ 0xF7F9EBE5CFC1D3DD87899B95BFB1A3AD<127:0> :
        /*3*/ 0x616F7D735957454B111F0D032927353B<127:0> :
        /*2*/ 0x818F9D93B9B7A5ABF1FFEDE3C9C7D5DB<127:0> :
        /*1*/ 0xBAB4A6A8828C9E90CAC4D6D8F2FCEEE0<127:0> :
        /*0*/ 0x5A544648626C7E702A243638121C0E00<127:0>
    );
    return FFmul_0E<UInt(b)*8+:8>;
```

## Library pseudocode for shared/functions/crypto/HaveAESExt

```
// HaveAESExt()
// =====
// TRUE if AES cryptographic instructions support is implemented,
// FALSE otherwise.

boolean HaveAESExt()
    return boolean IMPLEMENTATION_DEFINED "Has AES Crypto instructions";
```

### Library pseudocode for shared/functions/crypto/HaveBit128PMULLExt

```
// HaveBit128PMULLExt()
// =====
// TRUE if 128 bit form of PMULL instructions support is implemented,
// FALSE otherwise.

boolean HaveBit128PMULLExt()
    return boolean IMPLEMENTATION_DEFINED "Has 128-bit form of PMULL instructions";
```

### Library pseudocode for shared/functions/crypto/HaveSHA1Ext

```
// HaveSHA1Ext()
// =====
// TRUE if SHA1 cryptographic instructions support is implemented,
// FALSE otherwise.

boolean HaveSHA1Ext()
    return boolean IMPLEMENTATION_DEFINED "Has SHA1 Crypto instructions";
```

### Library pseudocode for shared/functions/crypto/HaveSHA256Ext

```
// HaveSHA256Ext()
// =====
// TRUE if SHA256 cryptographic instructions support is implemented,
// FALSE otherwise.

boolean HaveSHA256Ext()
    return boolean IMPLEMENTATION_DEFINED "Has SHA256 Crypto instructions";
```

### Library pseudocode for shared/functions/crypto/HaveSHA3Ext

```
// HaveSHA3Ext()
// =====
// TRUE if SHA3 cryptographic instructions support is implemented,
// and when SHA1 and SHA2 basic cryptographic instructions support is implemented,
// FALSE otherwise.

boolean HaveSHA3Ext()
    if !HasArchVersion\(ARMv8p2\) || !(HaveSHA1Ext\(\) && HaveSHA256Ext\(\)) then
        return FALSE;
    return boolean IMPLEMENTATION_DEFINED "Has SHA3 Crypto instructions";
```

### Library pseudocode for shared/functions/crypto/HaveSHA512Ext

```
// HaveSHA512Ext()
// =====
// TRUE if SHA512 cryptographic instructions support is implemented,
// and when SHA1 and SHA2 basic cryptographic instructions support is implemented,
// FALSE otherwise.

boolean HaveSHA512Ext()
    if !HasArchVersion\(ARMv8p2\) || !(HaveSHA1Ext\(\) && HaveSHA256Ext\(\)) then
        return FALSE;
    return boolean IMPLEMENTATION_DEFINED "Has SHA512 Crypto instructions";
```

### Library pseudocode for shared/functions/crypto/HaveSM3Ext

```
// HaveSM3Ext()
// =====
// TRUE if SM3 cryptographic instructions support is implemented,
// FALSE otherwise.

boolean HaveSM3Ext()
    if !HasArchVersion(ARMv8p2) then
        return FALSE;
    return boolean IMPLEMENTATION_DEFINED "Has SM3 Crypto instructions";
```

### Library pseudocode for shared/functions/crypto/HaveSM4Ext

```
// HaveSM4Ext()
// =====
// TRUE if SM4 cryptographic instructions support is implemented,
// FALSE otherwise.

boolean HaveSM4Ext()
    if !HasArchVersion(ARMv8p2) then
        return FALSE;
    return boolean IMPLEMENTATION_DEFINED "Has SM4 Crypto instructions";
```

### Library pseudocode for shared/functions/crypto/ROL

```
// ROL()
// =====

bits(N) ROL(bits(N) x, integer shift)
    assert shift >= 0 && shift <= N;
    if (shift == 0) then
        return x;
    return ROR(x, N-shift);
```

### Library pseudocode for shared/functions/crypto/SHA256hash

```
// SHA256hash()
// =====

bits(128) SHA256hash(bits (128) X, bits(128) Y, bits(128) W, boolean part1)
    bits(32) chs, maj, t;

    for e = 0 to 3
        chs = SHAchoose(Y<31:0>, Y<63:32>, Y<95:64>);
        maj = SHAmajority(X<31:0>, X<63:32>, X<95:64>);
        t = Y<127:96> + SHAhashSIGMA1(Y<31:0>) + chs + Elem[W, e, 32];
        X<127:96> = t + X<127:96>;
        Y<127:96> = t + SHAhashSIGMA0(X<31:0>) + maj;
        <Y, X> = ROL(Y : X, 32);
    return (if part1 then X else Y);
```

### Library pseudocode for shared/functions/crypto/SHAchoose

```
// SHAchoose()
// =====

bits(32) SHAchoose(bits(32) x, bits(32) y, bits(32) z)
    return ((y EOR z) AND x) EOR z;
```

### Library pseudocode for shared/functions/crypto/SHAhashSIGMA0

```
// SHAhashSIGMA0()
// =====

bits(32) SHAhashSIGMA0(bits(32) x)
    return ROR(x, 2) EOR ROR(x, 13) EOR ROR(x, 22);
```

### Library pseudocode for shared/functions/crypto/SHAhashSIGMA1

```
// SHAhashSIGMA1()
// =====

bits(32) SHAhashSIGMA1(bits(32) x)
    return ROR(x, 6) EOR ROR(x, 11) EOR ROR(x, 25);
```

### Library pseudocode for shared/functions/crypto/SHAmajority

```
// SHAmajority()
// =====

bits(32) SHAmajority(bits(32) x, bits(32) y, bits(32) z)
    return ((x AND y) OR ((x OR y) AND z));
```

### Library pseudocode for shared/functions/crypto/SHAparity

```
// SHAparity()
// =====

bits(32) SHAparity(bits(32) x, bits(32) y, bits(32) z)
    return (x EOR y EOR z);
```

### Library pseudocode for shared/functions/crypto/Sbox

```
// Sbox()
// =====
// Used in SM4E crypto instruction

bits(8) Sbox(bits(8) sboxin)
    bits(8) sboxout;
    bits(2048) sboxstring = 0xd690e9fecce13db716b614c228fb2c052b679a762abe04c3aa441326498606999c4250f491e
    sboxout = sboxstring<(255-UInt(sboxin))*8+7:(255-UInt(sboxin))*8>;
    return sboxout;
```

### Library pseudocode for shared/functions/exclusive/ClearExclusiveByAddress

```
// Clear the global Exclusives monitors for all PEs EXCEPT processorid if they
// record any part of the physical address region of size bytes starting at paddress.
// It is IMPLEMENTATION DEFINED whether the global Exclusives monitor for processorid
// is also cleared if it records any part of the address region.
ClearExclusiveByAddress(FullAddress paddress, integer processorid, integer size);
```

### Library pseudocode for shared/functions/exclusive/ClearExclusiveLocal

```
// Clear the local Exclusives monitor for the specified processorid.
ClearExclusiveLocal(integer processorid);
```



### Library pseudocode for shared/functions/exclusive/ClearExclusiveMonitors

```
// ClearExclusiveMonitors()
// =====
// Clear the local Exclusives monitor for the executing PE.

ClearExclusiveMonitors()
    ClearExclusiveLocal(ProcessorID());
```

### Library pseudocode for shared/functions/exclusive/ExclusiveMonitorsStatus

```
// Returns '0' to indicate success if the last memory write by this PE was to
// the same physical address region endorsed by ExclusiveMonitorsPass().
// Returns '1' to indicate failure if address translation resulted in a different
// physical address.
bit ExclusiveMonitorsStatus();
```

### Library pseudocode for shared/functions/exclusive/IsExclusiveGlobal

```
// Return TRUE if the global Exclusives monitor for processorid includes all of
// the physical address region of size bytes starting at address.
boolean IsExclusiveGlobal(FullAddress address, integer processorid, integer size);
```

### Library pseudocode for shared/functions/exclusive/IsExclusiveLocal

```
// Return TRUE if the local Exclusives monitor for processorid includes all of
// the physical address region of size bytes starting at address.
boolean IsExclusiveLocal(FullAddress address, integer processorid, integer size);
```

### Library pseudocode for shared/functions/exclusive/MarkExclusiveGlobal

```
// Record the physical address region of size bytes starting at address in
// the global Exclusives monitor for processorid.
MarkExclusiveGlobal(FullAddress address, integer processorid, integer size);
```

### Library pseudocode for shared/functions/exclusive/MarkExclusiveLocal

```
// Record the physical address region of size bytes starting at address in
// the local Exclusives monitor for processorid.
MarkExclusiveLocal(FullAddress address, integer processorid, integer size);
```

### Library pseudocode for shared/functions/exclusive/ProcessorID

```
// Return the ID of the currently executing PE.
integer ProcessorID();
```

### Library pseudocode for shared/functions/extension/AArch32.HaveHPDExt

```
// AArch32.HaveHPDExt()
// =====

boolean AArch32.HaveHPDExt()
    return HasArchVersion(ARMv8p2);
```

### Library pseudocode for shared/functions/extension/AArch64.HaveHPDExt

```
// AArch64.HaveHPDExt()
// =====

boolean AArch64.HaveHPDExt()
    return HasArchVersion(ARMv8p1);
```

### Library pseudocode for shared/functions/extension/Have52BitIPAAndPASpaceExt

```
// Have52BitIPAAndPASpaceExt()
// =====
// Returns TRUE if 52-bit IPA and PA extension support
// is implemented, and FALSE otherwise.

boolean Have52BitIPAAndPASpaceExt()
    return (HasArchVersion(ARMv8p7) &&
        boolean IMPLEMENTATION_DEFINED "Has 52-bit IPA and PA support" &&
        Have52BitVAExt() && Have52BitPAExt());
```

### Library pseudocode for shared/functions/extension/Have52BitPAExt

```
// Have52BitPAExt()
// =====
// Returns TRUE if Large Physical Address extension
// support is implemented and FALSE otherwise.

boolean Have52BitPAExt()
    return HasArchVersion(ARMv8p2) && boolean IMPLEMENTATION_DEFINED "Has large 52-bit PA/IPA support";
```

### Library pseudocode for shared/functions/extension/Have52BitVAExt

```
// Have52BitVAExt()
// =====
// Returns TRUE if Large Virtual Address extension
// support is implemented and FALSE otherwise.

boolean Have52BitVAExt()
    return HasArchVersion(ARMv8p2) && boolean IMPLEMENTATION_DEFINED "Has large 52-bit VA support";
```

### Library pseudocode for shared/functions/extension/HaveAArch32BF16Ext

```
// HaveAArch32BF16Ext()
// =====
// Returns TRUE if AArch32 BFloat16 instruction support is implemented, and FALSE otherwise.

boolean HaveAArch32BF16Ext()
    return HasArchVersion(ARMv8p2) && boolean IMPLEMENTATION_DEFINED "Has AArch32 BFloat16 extension";
```

### Library pseudocode for shared/functions/extension/HaveAArch32Int8MatMulExt

```
// HaveAArch32Int8MatMulExt()
// =====
// Returns TRUE if AArch32 8-bit integer matrix multiply instruction support
// is implemented, and FALSE otherwise.

boolean HaveAArch32Int8MatMulExt()
    return HasArchVersion(ARMv8p2) && boolean IMPLEMENTATION_DEFINED "Has AArch32 Int8 Mat Mul extension";
```

### Library pseudocode for shared/functions/extension/HaveAltFP

```
// HaveAltFP()
// =====
// Returns TRUE if alternative Floating-point extension support
// is implemented, and FALSE otherwise.

boolean HaveAltFP()
    return HasArchVersion(ARMv8p7);
```

### Library pseudocode for shared/functions/extension/HaveAtomicExt

```
// HaveAtomicExt()  
// =====  
  
boolean HaveAtomicExt()  
    return HasArchVersion(ARMv8p1);
```

### Library pseudocode for shared/functions/extension/HaveBF16Ext

```
// HaveBF16Ext()  
// =====  
// Returns TRUE if AArch64 BFloat16 instruction support is implemented, and FALSE otherwise.  
  
boolean HaveBF16Ext()  
    return HasArchVersion(ARMv8p6) || (HasArchVersion(ARMv8p2) && boolean IMPLEMENTATION_DEFINED "Has AArch64 BF16 extension");
```

### Library pseudocode for shared/functions/extension/HaveBTIExt

```
// HaveBTIExt()  
// =====  
// Returns TRUE if support for Branch Target Identification is implemented.  
  
boolean HaveBTIExt()  
    return HasArchVersion(ARMv8p5);
```

### Library pseudocode for shared/functions/extension/HaveBlockBBM

```
// HaveBlockBBM()  
// =====  
// Returns TRUE if support for changing block size without requiring break-before-make is implemented.  
  
boolean HaveBlockBBM()  
    return HasArchVersion(ARMv8p4);
```

### Library pseudocode for shared/functions/extension/HaveCommonNotPrivateTransExt

```
// HaveCommonNotPrivateTransExt()  
// =====  
  
boolean HaveCommonNotPrivateTransExt()  
    return HasArchVersion(ARMv8p2);
```

### Library pseudocode for shared/functions/extension/HaveDGHEExt

```
// HaveDGHEExt()  
// =====  
// Returns TRUE if Data Gathering Hint instruction support is implemented, and FALSE otherwise.  
  
boolean HaveDGHEExt()  
    return boolean IMPLEMENTATION_DEFINED "Has AArch64 DGH extension";
```

### Library pseudocode for shared/functions/extension/HaveDITExt

```
// HaveDITExt()  
// =====  
  
boolean HaveDITExt()  
    return HasArchVersion(ARMv8p4);
```

### Library pseudocode for shared/functions/extension/HaveDOTPExt

```
// HaveDOTPExt()  
// =====  
// Returns TRUE if Dot Product feature support is implemented, and FALSE otherwise.  
  
boolean HaveDOTPExt()  
    return HasArchVersion(ARMv8p4) || (HasArchVersion(ARMv8p2) && boolean IMPLEMENTATION_DEFINED "Has Dot Product feature support");
```

### Library pseudocode for shared/functions/extension/HaveDoPD

```
// HaveDoPD()  
// =====  
// Returns TRUE if Debug Over Power Down extension  
// support is implemented and FALSE otherwise.  
  
boolean HaveDoPD()  
    return HasArchVersion(ARMv8p2) && boolean IMPLEMENTATION_DEFINED "Has DoPD extension";
```

### Library pseudocode for shared/functions/extension/HaveDoubleFaultExt

```
// HaveDoubleFaultExt()  
// =====  
  
boolean HaveDoubleFaultExt()  
    return (HasArchVersion(ARMv8p4) && HaveEL(EL3) && !ELUsingAArch32(EL3) && HaveIESB());
```

### Library pseudocode for shared/functions/extension/HaveDoubleLock

```
// HaveDoubleLock()  
// =====  
// Returns TRUE if support for the OS Double Lock is implemented.  
  
boolean HaveDoubleLock()  
    return !HasArchVersion(ARMv8p4) || boolean IMPLEMENTATION_DEFINED "OS Double Lock is implemented";
```

### Library pseudocode for shared/functions/extension/HaveE0PDExt

```
// HaveE0PDExt()  
// =====  
// Returns TRUE if support for constant fault times for unprivileged accesses  
// to the memory map is implemented.  
  
boolean HaveE0PDExt()  
    return HasArchVersion(ARMv8p5);
```

### Library pseudocode for shared/functions/extension/HaveECVExt

```
// HaveECVExt()  
// =====  
// Returns TRUE if Enhanced Counter Virtualization extension  
// support is implemented, and FALSE otherwise.  
  
boolean HaveECVExt()  
    return HasArchVersion(ARMv8p6);
```

### Library pseudocode for shared/functions/extension/HaveEMPAMExt

```
// HaveEMPAMExt()
// =====
// Returns TRUE if Enhanced MPAM is implemented, and FALSE otherwise.

boolean HaveEMPAMExt()
    return (HasArchVersion(ARMv8p6) &&
            HaveMPAMExt() &&
            boolean IMPLEMENTATION_DEFINED "Has enhanced MPAM extension");
```

### Library pseudocode for shared/functions/extension/HaveExtendedCacheSets

```
// HaveExtendedCacheSets()
// =====

boolean HaveExtendedCacheSets()
    return HasArchVersion(ARMv8p3);
```

### Library pseudocode for shared/functions/extension/HaveExtendedECDebugEvents

```
// HaveExtendedECDebugEvents()
// =====

boolean HaveExtendedECDebugEvents()
    return HasArchVersion(ARMv8p2);
```

### Library pseudocode for shared/functions/extension/HaveExtendedExecuteNeverExt

```
// HaveExtendedExecuteNeverExt()
// =====

boolean HaveExtendedExecuteNeverExt()
    return HasArchVersion(ARMv8p2);
```

### Library pseudocode for shared/functions/extension/HaveFCADDExt

```
// HaveFCADDExt()
// =====

boolean HaveFCADDExt()
    return HasArchVersion(ARMv8p3);
```

### Library pseudocode for shared/functions/extension/HaveFGTEExt

```
// HaveFGTEExt()
// =====
// Returns TRUE if Fine Grained Trap is implemented, and FALSE otherwise.

boolean HaveFGTEExt()
    return HasArchVersion(ARMv8p6) && !ELUsingAArch32(EL2);
```

### Library pseudocode for shared/functions/extension/HaveFJCVTZSExt

```
// HaveFJCVTZSExt()
// =====

boolean HaveFJCVTZSExt()
    return HasArchVersion(ARMv8p3);
```

### Library pseudocode for shared/functions/extension/HaveFP16MulNoRoundingToFP32Ext

```
// HaveFP16MulNoRoundingToFP32Ext()
// =====
// Returns TRUE if has FP16 multiply with no intermediate rounding accumulate to FP32 instructions,
// and FALSE otherwise

boolean HaveFP16MulNoRoundingToFP32Ext()
    if !HaveFP16Ext() then return FALSE;
    if HasArchVersion(ARMv8p4) then return TRUE;
    return (HasArchVersion(ARMv8p2) &&
        boolean IMPLEMENTATION_DEFINED "Has accumulate FP16 product into FP32 extension");
```

### Library pseudocode for shared/functions/extension/HaveFeatHCX

```
// HaveFeatHCX()
// =====
// Returns TRUE if HCRX_EL2 Trap Control register is implemented,
// and FALSE otherwise.

boolean HaveFeatHCX()
    return HasArchVersion(ARMv8p7);
```

### Library pseudocode for shared/functions/extension/HaveFeatLS64

```
// HaveFeatLS64()
// =====
// Returns TRUE if the LD64B, ST64B, ST64BV, and ST64BV0 instructions are
// supported, and FALSE otherwise.

boolean HaveFeatLS64()
    return (HasArchVersion(ARMv8p7) &&
        boolean IMPLEMENTATION_DEFINED "Has Load Store 64-Byte instruction support");
```

### Library pseudocode for shared/functions/extension/HaveFeatRPRES

```
// HaveFeatRPRES()
// =====
// Returns TRUE if reciprocal estimate implements 12-bit precision
// when FPCR.AH=1, and FALSE otherwise.

boolean HaveFeatRPRES()
    return (HasArchVersion(ARMv8p7) &&
        (boolean IMPLEMENTATION_DEFINED "Has increased Reciprocal Estimate and Square Root Estimate precision")
        HaveAltFP());
```

### Library pseudocode for shared/functions/extension/HaveFeatWFXt

```
// HaveFeatWFXt()
// =====
// Returns TRUE if WFET and WFIT instruction support is implemented,
// and FALSE otherwise.

boolean HaveFeatWFXt()
    return HasArchVersion(ARMv8p7);
```

### Library pseudocode for shared/functions/extension/HaveFeatXS

```
// HaveFeatXS()
// =====
// Returns TRUE if XS attribute and the TLBI and DSB instructions with nXS qualifier
// are supported, and FALSE otherwise.

boolean HaveFeatXS()
    return HasArchVersion(ARMv8p7);
```

### Library pseudocode for shared/functions/extension/HaveFlagFormatExt

```
// HaveFlagFormatExt()
// =====
// Returns TRUE if flag format conversion instructions implemented.

boolean HaveFlagFormatExt()
    return HasArchVersion\(ARMv8p5\);
```

### Library pseudocode for shared/functions/extension/HaveFlagManipulateExt

```
// HaveFlagManipulateExt()
// =====
// Returns TRUE if flag manipulate instructions are implemented.

boolean HaveFlagManipulateExt()
    return HasArchVersion\(ARMv8p4\);
```

### Library pseudocode for shared/functions/extension/HaveFrintExt

```
// HaveFrintExt()
// =====
// Returns TRUE if FRINT instructions are implemented.

boolean HaveFrintExt()
    return HasArchVersion\(ARMv8p5\);
```

### Library pseudocode for shared/functions/extension/HaveHPMDExt

```
// HaveHPMDExt()
// =====

boolean HaveHPMDExt()
    return HasArchVersion\(ARMv8p1\);
```

### Library pseudocode for shared/functions/extension/HaveIDSExt

```
// HaveIDSExt()
// =====
// Returns TRUE if ID register handling feature is implemented.

boolean HaveIDSExt()
    return HasArchVersion\(ARMv8p4\);
```

### Library pseudocode for shared/functions/extension/HaveIESB

```
// HaveIESB()
// =====

boolean HaveIESB()
    return (HaveRASExt\(\) &&
        boolean IMPLEMENTATION_DEFINED "Has Implicit Error Synchronization Barrier");
```

### Library pseudocode for shared/functions/extension/HaveInt8MatMulExt

```
// HaveInt8MatMulExt()
// =====
// Returns TRUE if AArch64 8-bit integer matrix multiply instruction support
// implemented, and FALSE otherwise.

boolean HaveInt8MatMulExt()
    return HasArchVersion\(ARMv8p6\) || (HasArchVersion\(ARMv8p2\) && boolean IMPLEMENTATION_DEFINED "Has AA
```

### Library pseudocode for shared/functions/extension/HaveLSE2Ext

```
// HaveLSE2Ext()
// =====
// Returns TRUE if LSE2 is implemented, and FALSE otherwise.

boolean HaveLSE2Ext()
    return HasArchVersion\(ARMv8p4\);
```

### Library pseudocode for shared/functions/extension/HaveMPAMExt

```
// HaveMPAMExt()
// =====
// Returns TRUE if MPAM is implemented, and FALSE otherwise.

boolean HaveMPAMExt()
    return (HasArchVersion\(ARMv8p2\) &&
        boolean IMPLEMENTATION_DEFINED "Has MPAM extension");
```

### Library pseudocode for shared/functions/extension/HaveMTE2Ext

```
// HaveMTE2Ext()
// =====
// Returns TRUE if MTE support is beyond EL0, and FALSE otherwise.

boolean HaveMTE2Ext()
    if !HasArchVersion\(ARMv8p5\) then
        return FALSE;
    return boolean IMPLEMENTATION_DEFINED "Has MTE2 extension";
```

### Library pseudocode for shared/functions/extension/HaveMTE3Ext

```
// HaveMTE3Ext()
// =====
// Returns TRUE if MTE Asymmetric Fault Handling support is
// implemented, and FALSE otherwise.

boolean HaveMTE3Ext()
    return ((HasArchVersion\(ARMv8p7\) && HaveMTE2Ext\(\)) || (HasArchVersion\(ARMv8p5\) &&
        boolean IMPLEMENTATION_DEFINED "Has MTE3 extension"));
```

### Library pseudocode for shared/functions/extension/HaveMTEExt

```
// HaveMTEExt()
// =====
// Returns TRUE if MTE implemented, and FALSE otherwise.

boolean HaveMTEExt()
    if !HasArchVersion\(ARMv8p5\) then
        return FALSE;
    if HaveMTE2Ext\(\) then
        return TRUE;
    return boolean IMPLEMENTATION_DEFINED "Has MTE extension";
```

### Library pseudocode for shared/functions/extension/HaveNV2Ext

```
// HaveNV2Ext()
// =====
// Returns TRUE if Enhanced Nested Virtualization is implemented.

boolean HaveNV2Ext()
    return (HasArchVersion\(ARMv8p4\) && HaveNVExt\(\)
        && boolean IMPLEMENTATION_DEFINED "Has support for Enhanced Nested Virtualization");
```



### Library pseudocode for shared/functions/extension/HaveNVExt

```
// HaveNVExt()  
// =====  
// Returns TRUE if Nested Virtualization is implemented.  
  
boolean HaveNVExt()  
    return HasArchVersion\(ARMv8p3\) && boolean IMPLEMENTATION_DEFINED "Has Nested Virtualization";
```

### Library pseudocode for shared/functions/extension/HaveNoSecurePMUDisableOverride

```
// HaveNoSecurePMUDisableOverride()  
// =====  
  
boolean HaveNoSecurePMUDisableOverride()  
    return HasArchVersion\(ARMv8p2\);
```

### Library pseudocode for shared/functions/extension/HaveNoninvasiveDebugAuth

```
// HaveNoninvasiveDebugAuth()  
// =====  
// Returns TRUE if the Non-invasive debug controls are implemented.  
  
boolean HaveNoninvasiveDebugAuth()  
    return !HasArchVersion\(ARMv8p4\);
```

### Library pseudocode for shared/functions/extension/HavePAN3Ext

```
// HavePAN3Ext()  
// =====  
// Returns TRUE if SCTL_EL1.EPAN and SCTL_EL2.EPAN support is implemented,  
// and FALSE otherwise.  
  
boolean HavePAN3Ext()  
    return HasArchVersion\(ARMv8p7\) || (HasArchVersion\(ARMv8p1\) &&  
        boolean IMPLEMENTATION_DEFINED "Has PAN3 extension");
```

### Library pseudocode for shared/functions/extension/HavePANExt

```
// HavePANExt()  
// =====  
  
boolean HavePANExt()  
    return HasArchVersion\(ARMv8p1\);
```

### Library pseudocode for shared/functions/extension/HavePMUv3p7

```
// HavePMUv3p7()  
// =====  
// Returns TRUE if the PMUv3p7 extension is implemented, and FALSE otherwise.  
  
boolean HavePMUv3p7()  
    return (HasArchVersion\(ARMv8p7\) && Havev85PMU\(\) &&  
        boolean IMPLEMENTATION_DEFINED "Has PMUv3p7 extension");
```

### Library pseudocode for shared/functions/extension/HavePageBasedHardwareAttributes

```
// HavePageBasedHardwareAttributes()  
// =====  
  
boolean HavePageBasedHardwareAttributes()  
    return HasArchVersion\(ARMv8p2\);
```

### Library pseudocode for shared/functions/extension/HavePrivAText

```
// HavePrivAText()
// =====

boolean HavePrivAText()
    return HasArchVersion(ARMv8p2);
```

### Library pseudocode for shared/functions/extension/HaveQRDMLAExt

```
// HaveQRDMLAExt()
// =====

boolean HaveQRDMLAExt()
    return HasArchVersion(ARMv8p1);

boolean HaveAccessFlagUpdateExt()
    return HasArchVersion(ARMv8p1);

boolean HaveDirtyBitModifierExt()
    return HasArchVersion(ARMv8p1);
```

### Library pseudocode for shared/functions/extension/HaveRASExt

```
// HaveRASExt()
// =====

boolean HaveRASExt()
    return (HasArchVersion(ARMv8p2) ||
            boolean IMPLEMENTATION_DEFINED "Has RAS extension");
```

### Library pseudocode for shared/functions/extension/HaveRNG

```
// HaveRNG()
// =====
// Returns TRUE if Random Number Generator extension
// support is implemented and FALSE otherwise.

boolean HaveRNG()
    return HasArchVersion(ARMv8p5) && boolean IMPLEMENTATION_DEFINED "Has RNG extension";
```

### Library pseudocode for shared/functions/extension/HaveSBExt

```
// HaveSBExt()
// =====
// Returns TRUE if support for SB is implemented, and FALSE otherwise.

boolean HaveSBExt()
    return HasArchVersion(ARMv8p5) || boolean IMPLEMENTATION_DEFINED "Has SB extension";
```

### Library pseudocode for shared/functions/extension/HaveSSBSExt

```
// HaveSSBSExt()
// =====
// Returns TRUE if support for SSBS is implemented, and FALSE otherwise.

boolean HaveSSBSExt()
    return HasArchVersion(ARMv8p5) || boolean IMPLEMENTATION_DEFINED "Has SSBS extension";
```

### Library pseudocode for shared/functions/extension/HaveSecureEL2Ext

```
// HaveSecureEL2Ext()
// =====
// Returns TRUE if Secure EL2 is implemented.

boolean HaveSecureEL2Ext()
    return HasArchVersion(ARMv8p4);
```

### Library pseudocode for shared/functions/extension/HaveSecureExtDebugView

```
// HaveSecureExtDebugView()
// =====
// Returns TRUE if support for Secure and Non-secure views of debug peripherals is implemented.

boolean HaveSecureExtDebugView()
    return HasArchVersion(ARMv8p4);
```

### Library pseudocode for shared/functions/extension/HaveSelfHostedTrace

```
// HaveSelfHostedTrace()
// =====

boolean HaveSelfHostedTrace()
    return HasArchVersion(ARMv8p4);
```

### Library pseudocode for shared/functions/extension/HaveSmallTranslationTblExt

```
// HaveSmallTranslationTblExt()
// =====
// Returns TRUE if Small Translation Table Support is implemented.

boolean HaveSmallTranslationTableExt()
    return HasArchVersion(ARMv8p4) && boolean IMPLEMENTATION_DEFINED "Has Small Translation Table extension";
```

### Library pseudocode for shared/functions/extension/HaveSoftwareLock

```
// HaveSoftwareLock()
// =====
// Returns TRUE if Software Lock is implemented.

boolean HaveSoftwareLock(Component component)
    if Havev8p4Debug() then
        return FALSE;
    if HaveDoPD() && component != Component_CTI then
        return FALSE;
    case component of
        when Component_Debug
            return boolean IMPLEMENTATION_DEFINED "Debug has Software Lock";
        when Component_PMU
            return boolean IMPLEMENTATION_DEFINED "PMU has Software Lock";
        when Component_CTI
            return boolean IMPLEMENTATION_DEFINED "CTI has Software Lock";
        otherwise
            Unreachable();
```

### Library pseudocode for shared/functions/extension/HaveStage2MemAttrControl

```
// HaveStage2MemAttrControl()
// =====
// Returns TRUE if support for Stage2 control of memory types and cacheability attributes is implemented.

boolean HaveStage2MemAttrControl()
    return HasArchVersion(ARMv8p4);
```

## Library pseudocode for shared/functions/extension/HaveStatisticalProfiling

```
// HaveStatisticalProfiling()
// =====
// Returns TRUE if Statistical Profiling Extension is implemented,
// and FALSE otherwise.

boolean HaveStatisticalProfiling()
    return HasArchVersion\(ARMv8p2\);
```

## Library pseudocode for shared/functions/extension/HaveStatisticalProfilingv1p1

```
// HaveStatisticalProfilingv1p1()
// =====
// Returns TRUE if the SPEv1p1 extension is implemented, and FALSE otherwise.

boolean HaveStatisticalProfilingv1p1()
    return (HasArchVersion\(ARMv8p3\) &&
        boolean IMPLEMENTATION_DEFINED "Has SPEv1p1 extension");
```

## Library pseudocode for shared/functions/extension/HaveStatisticalProfilingv1p2

```
// HaveStatisticalProfilingv1p2()
// =====
// Returns TRUE if the SPEv1p2 extension is implemented, and FALSE otherwise.

boolean HaveStatisticalProfilingv1p2()
    return (HasArchVersion\(ARMv8p7\) && HaveStatisticalProfiling\(\) &&
        boolean IMPLEMENTATION_DEFINED "Has SPEv1p2 extension");
```

## Library pseudocode for shared/functions/extension/HaveTWEDEExt

```
// HaveTWEDEExt()
// =====
// Returns TRUE if Delayed Trapping of WFE instruction support is implemented, and FALSE otherwise.

boolean HaveTWEDEExt()
    return boolean IMPLEMENTATION_DEFINED "Has TWED extension";
```

## Library pseudocode for shared/functions/extension/HaveTraceExt

```
// HaveTraceExt()
// =====
// Returns TRUE if Trace functionality as described by the Trace Architecture
// is implemented.

boolean HaveTraceExt()
    return boolean IMPLEMENTATION_DEFINED "Has Trace Architecture functionality";
```

## Library pseudocode for shared/functions/extension/HaveTrapLoadStoreMultipleDeviceExt

```
// HaveTrapLoadStoreMultipleDeviceExt()
// =====

boolean HaveTrapLoadStoreMultipleDeviceExt()
    return HasArchVersion\(ARMv8p2\);
```

## Library pseudocode for shared/functions/extension/HaveUAOExt

```
// HaveUAOExt()
// =====

boolean HaveUAOExt()
    return HasArchVersion\(ARMv8p2\);
```

### Library pseudocode for shared/functions/extension/HaveV82Debug

```
// HaveV82Debug()  
// =====  
  
boolean HaveV82Debug()  
    return HasArchVersion\(ARMv8p2\);
```

### Library pseudocode for shared/functions/extension/HaveVirtHostExt

```
// HaveVirtHostExt()  
// =====  
  
boolean HaveVirtHostExt()  
    return HasArchVersion\(ARMv8p1\);
```

### Library pseudocode for shared/functions/extension/Havev85PMU

```
// Havev85PMU()  
// =====  
// Returns TRUE if v8.5-Performance Monitor Unit extension  
// support is implemented, and FALSE otherwise.  
  
boolean Havev85PMU()  
    return HasArchVersion\(ARMv8p5\) && boolean IMPLEMENTATION_DEFINED "Has PMUv3p5 extension";
```

### Library pseudocode for shared/functions/extension/Havev8p4Debug

```
// Havev8p4Debug()  
// =====  
// Returns TRUE if support for the Debugv8p4 feature is implemented and FALSE otherwise.  
  
boolean Havev8p4Debug()  
    return HasArchVersion\(ARMv8p4\);
```

### Library pseudocode for shared/functions/extension/InsertIESBBeforeException

```
// If SCTLR_ELx.IESB is 1 when an exception is generated to ELx, any pending Unrecoverable  
// SError interrupt must be taken before executing any instructions in the exception handler.  
// However, this can be before the branch to the exception handler is made.  
boolean InsertIESBBeforeException(bits(2) el);
```

## Library pseudocode for shared/functions/float/bfloat/BFAdd

```
// BFAdd()
// =====
// Single-precision add following BFloat16 computation behaviors.

bits(32) BFAdd(bits(32) op1, bits(32) op2)

    bits(32) result;

    FPCRTyp fpcr = FPCR[];
    (type1,sign1,value1) = BFUnpack(op1);
    (type2,sign2,value2) = BFUnpack(op2);
    if type1 == FPTyp_QNaN || type2 == FPTyp_QNaN then
        result = FPDefaultNaN(fpcr);
    else
        inf1 = (type1 == FPTyp_Infinity);
        inf2 = (type2 == FPTyp_Infinity);
        zero1 = (type1 == FPTyp_Zero);
        zero2 = (type2 == FPTyp_Zero);
        if inf1 && inf2 && sign1 == NOT(sign2) then
            result = FPDefaultNaN(fpcr);
        elseif (inf1 && sign1 == '0') || (inf2 && sign2 == '0') then
            result = FPInfinity('0');
        elseif (inf1 && sign1 == '1') || (inf2 && sign2 == '1') then
            result = FPInfinity('1');
        elseif zero1 && zero2 && sign1 == sign2 then
            result = FPZero(sign1);
        else
            result_value = value1 + value2;
            if result_value == 0.0 then
                result = FPZero('0'); // Positive sign when Round to Odd
            else
                result = BFRound(result_value);

    return result;
```

## Library pseudocode for shared/functions/float/bfloat/BFDotAdd

```
// BFDotAdd()
// =====
// BFloat16 2-way dot-product and add to single-precision
// result = addend + op1_a*op2_a + op1_b*op2_b

bits(32) BFDotAdd(bits(32) addend, bits(16) op1_a, bits(16) op1_b,
                  bits(16) op2_a, bits(16) op2_b, FPCRTyp fpcr)

    bits(32) prod;

    prod = BFAdd(BFMul(op1_a, op2_a), BFMul(op1_b, op2_b));
    result = BFAdd(addend, prod);

    return result;
```

## Library pseudocode for shared/functions/float/bfloat/BFMatMulAdd

```
// BFMatMulAdd()
// =====
// BFloat16 matrix multiply and add to single-precision matrix
// result[2, 2] = addend[2, 2] + (op1[2, 4] * op2[4, 2])

bits(N) BFMatMulAdd(bits(N) addend, bits(N) op1, bits(N) op2)

    assert N == 128;

    bits(N) result;
    bits(32) sum;

    for i = 0 to 1
        for j = 0 to 1
            sum = Elem[addend, 2*i + j, 32];
            for k = 0 to 1
                bits(16) elt1_a = Elem[op1, 4*i + 2*k + 0, 16];
                bits(16) elt1_b = Elem[op1, 4*i + 2*k + 1, 16];
                bits(16) elt2_a = Elem[op2, 4*j + 2*k + 0, 16];
                bits(16) elt2_b = Elem[op2, 4*j + 2*k + 1, 16];
                sum = BFDotAdd(sum, elt1_a, elt1_b, elt2_a, elt2_b, FPCR[]);
            Elem[result, 2*i + j, 32] = sum;

    return result;
```

## Library pseudocode for shared/functions/float/bfloat/BFMul

```
// BFMul()
// =====
// BFloat16 widening multiply to single-precision following BFloat16
// computation behaviors.

bits(32) BFMul(bits(16) op1, bits(16) op2)

    bits(32) result;

    FPCRType fpcr = FPCR[];
    (type1,sign1,value1) = BFUnpack(op1);
    (type2,sign2,value2) = BFUnpack(op2);
    if type1 == FPType_QNaN || type2 == FPType_QNaN then
        result = FPDefaultNaN(fpcr);
    else
        inf1 = (type1 == FPType_Infinity);
        inf2 = (type2 == FPType_Infinity);
        zero1 = (type1 == FPType_Zero);
        zero2 = (type2 == FPType_Zero);
        if (inf1 && zero2) || (zero1 && inf2) then
            result = FPDefaultNaN(fpcr);
        elsif inf1 || inf2 then
            result = FPIInfinity(sign1 EOR sign2);
        elsif zero1 || zero2 then
            result = FPZero(sign1 EOR sign2);
        else
            result = BFRound(value1*value2);

    return result;
```

## Library pseudocode for shared/functions/float/bfloat/BFMulAdd

```
// BFMulAdd()  
// =====  
// Used by BFMLALB and BFMLALT instructions.  
  
bits(N) BFMulAdd(bits(N) addend, bits(N) op1, bits(N) op2, FPCRTType fpcr)  
    boolean altfp = HaveAltFP() && fpcr.AH == '1'; // When TRUE:  
    boolean fpexc = !altfp;                        // Do not generate floating point exceptions  
    if altfp then fpcr.<FIZ,FZ> = '11';             // Flush denormal input and output to zero  
    if altfp then fpcr.RMode = '00';               // Use RNE rounding mode  
    return FPMulAdd(addend, op1, op2, fpcr, fpexc);
```

## Library pseudocode for shared/functions/float/bfloat/BFNeg

```
// BFNeg()  
// =====  
  
bits(16) BFNeg(bits(16) op)  
    return NOT(op<15>) : op<14:0>;
```



## Library pseudocode for shared/functions/float/bfloat/BFRound

```
// BFRound()
// =====
// Converts a real number OP into a single-precision value using the
// Round to Odd rounding mode and following BFloat16 computation behaviors.

bits(32) BFRound(real op)

    assert op != 0.0;
    bits(32) result;

    // Format parameters - minimum exponent, numbers of exponent and fraction bits.
    minimum_exp = -126;  E = 8;  F = 23;

    // Split value into sign, unrounded mantissa and exponent.
    if op < 0.0 then
        sign = '1';  mantissa = -op;
    else
        sign = '0';  mantissa = op;
    exponent = 0;
    while mantissa < 1.0 do
        mantissa = mantissa * 2.0;  exponent = exponent - 1;
    while mantissa >= 2.0 do
        mantissa = mantissa / 2.0;  exponent = exponent + 1;

    // Fixed Flush-to-zero.
    if exponent < minimum_exp then
        return FPZero(sign);

    // Start creating the exponent value for the result. Start by biasing the actual exponent
    // so that the minimum exponent becomes 1, lower values 0 (indicating possible underflow).
    biased_exp = Max(exponent - minimum_exp + 1, 0);
    if biased_exp == 0 then mantissa = mantissa / 2.0^(minimum_exp - exponent);

    // Get the unrounded mantissa as an integer, and the "units in last place" rounding error.
    int_mant = RoundDown(mantissa * 2.0^F);  // < 2.0^F if biased_exp == 0, >= 2.0^F if not
    error = mantissa * 2.0^F - Real(int_mant);

    // Round to Odd
    if error != 0.0 then
        int_mant<0> = '1';

    // Deal with overflow and generate result.
    if biased_exp >= 2^E - 1 then
        result = FPInfinity(sign);  // Overflows generate appropriately-signed Infinity
    else
        result = sign : biased_exp<30-F:0> : int_mant<F-1:0>;

    return result;
```

## Library pseudocode for shared/functions/float/bfloat/BFUnpack

```
// BFUnpack()
// =====
// Unpacks a BFloat16 or single-precision value into its type,
// sign bit and real number that it represents.
// The real number result has the correct sign for numbers and infinities,
// is very large in magnitude for infinities, and is 0.0 for NaNs.
// (These values are chosen to simplify the description of
// comparisons and conversions.)

(FPType, bit, real) BFUnpack(bits(N) fpval)

    assert N IN {16,32};

    if N == 16 then
        sign    = fpval<15>;
        exp     = fpval<14:7>;
        frac    = fpval<6:0> : Zeros(16);
    else // N == 32
        sign    = fpval<31>;
        exp     = fpval<30:23>;
        frac    = fpval<22:0>;

    if IsZero(exp) then
        fptype = FPType_Zero; value = 0.0;    // Fixed Flush to Zero
    elseif IsOnes(exp) then
        if IsZero(frac) then
            fptype = FPType_Infinity; value = 2.0^1000000;
        else // no SNaN for BF16 arithmetic
            fptype = FPType_QNaN; value = 0.0;
    else
        fptype = FPType_Nonzero;
        value = 2.0^(UInt(exp)-127) * (1.0 + Real(UInt(frac)) * 2.0^-23);

    if sign == '1' then value = -value;

    return (fptype, sign, value);
```

## Library pseudocode for shared/functions/float/bfloat/FPConvertBF

```
// FPConvertBF()
// =====
// Converts a single-precision OP to BFloat16 value with using rounding mode of
// Round to Nearest Even when executed from AArch64 state and
// FPCR.AH == '1', otherwise rounding is controlled by FPCR/FPSCR.

bits(16) FPConvertBF(bits(32) op, FPCRTYPE fpcr, FPRounding rounding)

    bits(32) result; // BF16 value in top 16 bits
    boolean altfp = HaveAltFP\(\) && !UsingAArch32\(\) && fpcr.AH == '1';
    boolean fpexc = !altfp; // Generate no floating-point exceptions
    if altfp then fpcr.<FIZ,FZ> = '11'; // Flush denormal input and output to zero
    if altfp then rounding = FPRounding\_TIEEVEN; // Use RNE rounding mode

    // Unpack floating-point operand, with always flush-to-zero if fpcr.AH == '1'.
    (fptype,sign,value) = FPUnpack(op, fpcr, fpexc);

    if fptype == FPTYPE\_SNaN || fptype == FPTYPE\_0NaN then
        if fpcr.DN == '1' then
            result = FPDefaultNaN(fpcr);
        else
            result = FPConvertNaN(op);
        if fptype == FPTYPE\_SNaN then
            if fpexc then FPProcessException(FPEXC\_InvalidOp, fpcr);
    elseif fptype == FPTYPE\_Infinity then
        result = FPInfinity(sign);
    elseif fptype == FPTYPE\_Zero then
        result = FPZero(sign);
    else
        result = FPRoundCVBF(value, fpcr, rounding, fpexc);

    // Returns correctly rounded BF16 value from top 16 bits
    return result<31:16>;

// FPConvertBF()
// =====
// Converts a single-precision operand to BFloat16 value.

bits(16) FPConvertBF(bits(32) op, FPCRTYPE fpcr)
    return FPConvertBF(op, fpcr, FPRoundingMode(fpcr));
```

## Library pseudocode for shared/functions/float/bfloat/FPRoundCVBF

```
// FPRoundCVBF()
// =====
// Converts a real number OP into a BFloat16 value using the supplied
// rounding mode RMODE. The 'fpexc' argument controls the generation of
// floating-point exceptions.

bits(32) FPRoundCVBF(real op, FPCRTYPE fpcr, FPRounding rounding, boolean fpexc)
    boolean isbfloat16 = TRUE;
    return FPRoundBase(op, fpcr, rounding, isbfloat16, fpexc);
```

## Library pseudocode for shared/functions/float/fixedtofp/FixedToFP

```
// FixedToFP()
// =====

// Convert M-bit fixed point OP with FBITS fractional bits to
// N-bit precision floating point, controlled by UNSIGNED and ROUNDING.

bits(N) FixedToFP(bits(M) op, integer fbits, boolean unsigned, FPCRTYPE fpcr, FPRounding rounding)

    assert N IN {16,32,64};
    assert M IN {16,32,64};
    bits(N) result;
    assert fbits >= 0;
    assert rounding != FPRounding\_ODD;

    // Correct signed-ness
    int_operand = Int(op, unsigned);

    // Scale by fractional bits and generate a real value
    real_operand = Real(int_operand) / 2.0^fbits;

    if real_operand == 0.0 then
        result = FPZero('0');
    else
        result = FPRound(real_operand, fpcr, rounding);

    return result;
```

## Library pseudocode for shared/functions/float/fpabs/FPAbs

```
// FPAbs()
// =====

bits(N) FPAbs(bits(N) op)

    assert N IN {16,32,64};
    if !UsingAArch32() && HaveAltFP() then
        FPCRTYPE fpcr = FPCR[];
        if fpcr.AH == '1' then
            (fptype, -, -) = FPUnpack(op, fpcr, FALSE);
            if fptype IN {FPTYPE\_SNaN, FPTYPE\_QNaN} then
                return op; // When fpcr.AH=1, sign of NaN has no consequence

    return '0' : op<N-2:0>;
```

## Library pseudocode for shared/functions/float/fpadd/FPAdd

```
// FPAdd()
// =====

bits(N) FPAdd(bits(N) op1, bits(N) op2, FPCRTType fpcr)
    boolean fpexc = TRUE;          // Generate floating-point exceptions
    return FPAdd(op1, op2, fpcr, fpexc);

// FPAdd()
// =====

bits(N) FPAdd(bits(N) op1, bits(N) op2, FPCRTType fpcr, boolean fpexc)

    assert N IN {16,32,64};
    rounding = FPRoundingMode(fpcr);

    (type1,sign1,value1) = FPUnpack(op1, fpcr, fpexc);
    (type2,sign2,value2) = FPUnpack(op2, fpcr, fpexc);

    boolean altfmaxfmin = FALSE;    // Do not use altfp mode for FMIN, FMAX and variants
    (done,result) = FPProcessNaNs(type1, type2, op1, op2, fpcr, altfmaxfmin, fpexc);
    if !done then
        inf1 = (type1 == FPType\_Infinity);  inf2 = (type2 == FPType\_Infinity);
        zero1 = (type1 == FPType\_Zero);      zero2 = (type2 == FPType\_Zero);
        if inf1 && inf2 && sign1 == NOT(sign2) then
            result = FPDefaultNaN(fpcr);
            if fpexc then FPProcessException(FPExc\_InvalidOp, fpcr);
        elsif (inf1 && sign1 == '0') || (inf2 && sign2 == '0') then
            result = FPInfinity('0');
        elsif (inf1 && sign1 == '1') || (inf2 && sign2 == '1') then
            result = FPInfinity('1');
        elsif zero1 && zero2 && sign1 == sign2 then
            result = FPZero(sign1);
        else
            result_value = value1 + value2;
            if result_value == 0.0 then // Sign of exact zero result depends on rounding mode
                result_sign = if rounding == FPRounding\_NEGINF then '1' else '0';
                result = FPZero(result_sign);
            else
                result = FPRound(result_value, fpcr, rounding, fpexc);

        if fpexc then FPProcessDenorms(type1, type2, N, fpcr);

    return result;
```

## Library pseudocode for shared/functions/float/fpcmpare/FPCompare

```
// FPCompare()
// =====

bits(4) FPCompare(bits(N) op1, bits(N) op2, boolean signal_nans, FPCRTType fpcr)

    assert N IN {16,32,64};
    (type1,sign1,value1) = FPUntpack(op1, fpcr);
    (type2,sign2,value2) = FPUntpack(op2, fpcr);

    if type1 IN {FPTType\_SNaN, FPTType\_QNaN} || type2 IN {FPTType\_SNaN, FPTType\_QNaN} then
        result = '0011';
        if type1 == FPTType\_SNaN || type2 == FPTType\_SNaN || signal_nans then
            FPProcessException(FPExc\_InvalidOp, fpcr);
    else
        // All non-NaN cases can be evaluated on the values produced by FPUntpack()
        if value1 == value2 then
            result = '0110';
        elseif value1 < value2 then
            result = '1000';
        else // value1 > value2
            result = '0010';

        FPProcessDenorms(type1, type2, N, fpcr);

    return result;
```

## Library pseudocode for shared/functions/float/fpcmpareeq/FPCompareEQ

```
// FPCompareEQ()
// =====

boolean FPCompareEQ(bits(N) op1, bits(N) op2, FPCRTType fpcr)

    assert N IN {16,32,64};
    (type1,sign1,value1) = FPUntpack(op1, fpcr);
    (type2,sign2,value2) = FPUntpack(op2, fpcr);

    if type1 IN {FPTType\_SNaN, FPTType\_QNaN} || type2 IN {FPTType\_SNaN, FPTType\_QNaN} then
        result = FALSE;
        if type1 == FPTType\_SNaN || type2 == FPTType\_SNaN then
            FPProcessException(FPExc\_InvalidOp, fpcr);
    else
        // All non-NaN cases can be evaluated on the values produced by FPUntpack()
        result = (value1 == value2);

        FPProcessDenorms(type1, type2, N, fpcr);

    return result;
```

## Library pseudocode for shared/functions/float/fpcmparege/FPCompareGE

```
// FPCompareGE()
// =====

boolean FPCompareGE(bits(N) op1, bits(N) op2, FPCRTType fpcr)

    assert N IN {16,32,64};
    (type1,sign1,value1) = FPUnpack(op1, fpcr);
    (type2,sign2,value2) = FPUnpack(op2, fpcr);

    if type1 IN {FPTType\_SNaN, FPTType\_QNaN} || type2 IN {FPTType\_SNaN, FPTType\_QNaN} then
        result = FALSE;
        FPProcessException(FPExc\_InvalidOp, fpcr);
    else
        // All non-NaN cases can be evaluated on the values produced by FPUnpack()
        result = (value1 >= value2);
        FPProcessDenorms(type1, type2, N, fpcr);

    return result;
```

## Library pseudocode for shared/functions/float/fpcmparegt/FPCompareGT

```
// FPCompareGT()
// =====

boolean FPCompareGT(bits(N) op1, bits(N) op2, FPCRTType fpcr)

    assert N IN {16,32,64};
    (type1,sign1,value1) = FPUnpack(op1, fpcr);
    (type2,sign2,value2) = FPUnpack(op2, fpcr);

    if type1 IN {FPTType\_SNaN, FPTType\_QNaN} || type2 IN {FPTType\_SNaN, FPTType\_QNaN} then
        result = FALSE;
        FPProcessException(FPExc\_InvalidOp, fpcr);
    else
        // All non-NaN cases can be evaluated on the values produced by FPUnpack()
        result = (value1 > value2);

        FPProcessDenorms(type1, type2, N, fpcr);

    return result;
```

## Library pseudocode for shared/functions/float/fpconvert/FPConvert

```
// FPConvert()
// =====

// Convert floating point OP with N-bit precision to M-bit precision,
// with rounding controlled by ROUNDING.
// This is used by the FP-to-FP conversion instructions and so for
// half-precision data ignores FZ16, but observes AHP.

bits(M) FPConvert(bits(N) op, FPCRTType fpcr, FPRounding rounding)

    assert M IN {16,32,64};
    assert N IN {16,32,64};
    bits(M) result;

    // Unpack floating-point operand optionally with flush-to-zero.
    (fptype,sign,value) = FPUnpackCV(op, fpcr);

    alt_hp = (M == 16) && (fpcr.AHP == '1');

    if fptype == FPTYPE\_SNaN || fptype == FPTYPE\_QNaN then
        if alt_hp then
            result = FPZero(sign);
        elsif fpcr.DN == '1' then
            result = FPDefaultNaN(fpcr);
        else
            result = FPConvertNaN(op);
            if fptype == FPTYPE\_SNaN || alt_hp then
                FPProcessException(FPExc\_InvalidOp,fpcr);
    elsif fptype == FPTYPE\_Infinity then
        if alt_hp then
            result = sign:Ones(M-1);
            FPProcessException(FPExc\_InvalidOp, fpcr);
        else
            result = FPInfinity(sign);
    elsif fptype == FPTYPE\_Zero then
        result = FPZero(sign);
    else
        result = FPRoundCV(value, fpcr, rounding);

        FPProcessDenorm(fptype, N, fpcr);

    return result;

// FPConvert()
// =====

bits(M) FPConvert(bits(N) op, FPCRTType fpcr)
    return FPConvert(op, fpcr, FPRoundingMode(fpcr));
```



## Library pseudocode for shared/functions/float/fpconvertnan/FPConvertNaN

```
// FPConvertNaN()
// =====
// Converts a NaN of one floating-point type to another

bits(M) FPConvertNaN(bits(N) op)

    assert N IN {16,32,64};
    assert M IN {16,32,64};
    bits(M) result;
    bits(51) frac;

    sign = op<N-1>;

    // Unpack payload from input NaN
    case N of
        when 64 frac = op<50:0>;
        when 32 frac = op<21:0>:Zeros(29);
        when 16 frac = op<8:0>:Zeros(42);

    // Repack payload into output NaN, while
    // converting an SNaN to a QNaN.
    case M of
        when 64 result = sign:Ones(M-52):frac;
        when 32 result = sign:Ones(M-23):frac<50:29>;
        when 16 result = sign:Ones(M-10):frac<50:42>;

    return result;
```

## Library pseudocode for shared/functions/float/fpcrtype/FPCRTType

```
type FPCRTType;
```

## Library pseudocode for shared/functions/float/fpdecoderm/FPDecodeRM

```
// FPDecodeRM()
// =====
// Decode most common AArch32 floating-point rounding encoding.

FPRounding FPDecodeRM(bits(2) rm)

    case rm of
        when '00' result = FPRounding_TIEAWAY; // A
        when '01' result = FPRounding_TIEEVEN; // N
        when '10' result = FPRounding_POSINF; // P
        when '11' result = FPRounding_NEGINF; // M

    return result;
```

## Library pseudocode for shared/functions/float/fpdecoderounding/FPDecodeRounding

```
// FPDecodeRounding()
// =====
// Decode floating-point rounding mode and common AArch64 encoding.

FPRounding FPDecodeRounding(bits(2) rmode)

    case rmode of
        when '00' return FPRounding_TIEEVEN; // N
        when '01' return FPRounding_POSINF; // P
        when '10' return FPRounding_NEGINF; // M
        when '11' return FPRounding_ZERO; // Z
```

## Library pseudocode for shared/functions/float/fpdefaultnan/FPDefaultNaN

```
// FPDefaultNaN()
// =====

bits(N) FPDefaultNaN()
    FPCRTYPE fpcr = FPCR[];
    return FPDefaultNaN(fpcr);

bits(N) FPDefaultNaN(FPCRTYPE fpcr)

    assert N IN {16,32,64};
    constant integer E = (if N == 16 then 5 elsif N == 32 then 8 else 11);
    constant integer F = N - (E + 1);
    bit sign = if HaveAltFP() && !UsingAArch32() then fpcr.AH else '0';

    bits(E) exp = Ones(E);
    bits(F) frac = '1':Zeros(F-1);

    return sign : exp : frac;
```

## Library pseudocode for shared/functions/float/fpdiv/FPDiv

```
// FPDiv()
// =====

bits(N) FPDiv(bits(N) op1, bits(N) op2, FPCRTYPE fpcr)

    assert N IN {16,32,64};
    (type1,sign1,value1) = FPUnpack(op1, fpcr);
    (type2,sign2,value2) = FPUnpack(op2, fpcr);
    (done,result) = FPProcessNaNs(type1, type2, op1, op2, fpcr);

    if !done then
        inf1 = type1 == FPTYPE_Infinity;
        inf2 = type2 == FPTYPE_Infinity;
        zero1 = type1 == FPTYPE_Zero;
        zero2 = type2 == FPTYPE_Zero;

        if (inf1 && inf2) || (zero1 && zero2) then
            result = FPDefaultNaN(fpcr);
            FPProcessException(FPExc_InvalidOp, fpcr);
        elsif inf1 || zero2 then
            result = FPInfinity(sign1 EOR sign2);
            if !inf1 then FPProcessException(FPExc_DivideByZero, fpcr);
        elsif zero1 || inf2 then
            result = FPZero(sign1 EOR sign2);
        else
            result = FPRound(value1/value2, fpcr);

        if !zero2 then
            FPProcessDenorms(type1, type2, N, fpcr);

    return result;
```

## Library pseudocode for shared/functions/float/fpexc/FPExc

```
enumeration FPExc
    {FPExc_InvalidOp, FPExc_DivideByZero, FPExc_Overflow,
     FPExc_Underflow, FPExc_Inexact, FPExc_InputDenorm};
```

## Library pseudocode for shared/functions/float/fpinfinity/FPIInfinity

```
// FPIInfinity()
// =====

bits(N) FPIInfinity(bit sign)

    assert N IN {16,32,64};
    constant integer E = (if N == 16 then 5 elsif N == 32 then 8 else 11);
    constant integer F = N - (E + 1);
    bits(E) exp = Ones(E);
    bits(F) frac = Zeros(F);

    return sign : exp : frac;
```

## Library pseudocode for shared/functions/float/fpmatmul/FPMatMulAdd

```
// FPMatMulAdd()
// =====
//
// Floating point matrix multiply and add to same precision matrix
// result[2, 2] = addend[2, 2] + (op1[2, 2] * op2[2, 2])

bits(N) FPMatMulAdd(bits(N) addend, bits(N) op1, bits(N) op2, integer esize, FPCRTType fpcr)

    assert N == esize * 2 * 2;
    bits(N) result;
    bits(esize) prod0, prod1, sum;

    for i = 0 to 1
        for j = 0 to 1
            sum = Elem[addend, 2*i + j, esize];
            prod0 = FPMul(Elem[op1, 2*i + 0, esize],
                        Elem[op2, 2*j + 0, esize], fpcr);
            prod1 = FPMul(Elem[op1, 2*i + 1, esize],
                        Elem[op2, 2*j + 1, esize], fpcr);
            sum = FPAAdd(sum, FPAAdd(prod0, prod1, fpcr), fpcr);
            Elem[result, 2*i + j, esize] = sum;

    return result;
```

## Library pseudocode for shared/functions/float/fpmax/FPMax

```
// FPMax()
// =====

bits(N) FPMax(bits(N) op1, bits(N) op2, FPCRTType fpcr)
    boolean altfp = HaveAltFP() && !UsingAArch32() && fpcr.AH == '1';
    return FPMax(op1, op2, fpcr, altfp);

// FPMax()
// =====
// Compare two inputs and return the larger value after rounding. The
// 'fpcr' argument supplies the FPCR control bits and 'altfp' determines
// if the function should use alternative floating-point behaviour.

bits(N) FPMax(bits(N) op1, bits(N) op2, FPCRTType fpcr, boolean altfp)

    assert N IN {16,32,64};
    (type1,sign1,value1) = FPUnpack(op1, fpcr);
    (type2,sign2,value2) = FPUnpack(op2, fpcr);

    if (altfp && type1 == FPTYPE\_Zero && type2 == FPTYPE\_Zero &&
        ((sign1 == '0' && sign2 == '1') || (sign1 == '1' && sign2 == '0'))) then
        return FPZero(sign2);

    (done,result) = FPProcessNaNs(type1, type2, op1, op2, fpcr, altfp, TRUE);

    if !done then
        if value1 > value2 then
            (ftype,sign,value) = (type1,sign1,value1);
        else
            (ftype,sign,value) = (type2,sign2,value2);
        if ftype == FPTYPE\_Infinity then
            result = FPInfinity(sign);
        elsif ftype == FPTYPE\_Zero then
            sign = sign1 AND sign2;          // Use most positive sign
            result = FPZero(sign);
        else
            // The use of FPRound() covers the case where there is a trapped underflow exception
            // for a denormalized number even though the result is exact.
            rounding = FPRoundingMode(fpcr);
            if altfp then // Denormal output is not flushed to zero
                fpcr.FZ = '0';
                fpcr.FZ16 = '0';

            result = FPRound(value, fpcr, rounding, TRUE);

            FPProcessDenorms(type1, type2, N, fpcr);

    return result;
```

## Library pseudocode for shared/functions/float/fpmaxnormal/FPMaxNormal

```
// FPMaxNormal()
// =====

bits(N) FPMaxNormal(bit sign)

    assert N IN {16,32,64};
    constant integer E = (if N == 16 then 5 elsif N == 32 then 8 else 11);
    constant integer F = N - (E + 1);
    exp = Ones(E-1):'0';
    frac = Ones(F);

    return sign : exp : frac;
```

## Library pseudocode for shared/functions/float/fpmaxnum/FPMaxNum

```
// FPMaxNum()
// =====

bits(N) FPMaxNum(bits(N) op1, bits(N) op2, FPCRTType fpcr)

    assert N IN {16,32,64};
    (type1,-,-) = FPUnpack(op1, fpcr);
    (type2,-,-) = FPUnpack(op2, fpcr);

    boolean type1_nan = type1 IN {FPTType\_QNaN, FPTType\_SNaN};
    boolean type2_nan = type2 IN {FPTType\_QNaN, FPTType\_SNaN};
    boolean altfp = HaveAltFP() && !UsingAArch32() && fpcr.AH == '1';

    if !(altfp && type1_nan && type2_nan) then
        // Treat a single quiet-NaN as -Infinity.
        if type1 == FPTType\_QNaN && type2 != FPTType\_QNaN then
            op1 = FPInfinity('1');
        elsif type1 != FPTType\_QNaN && type2 == FPTType\_QNaN then
            op2 = FPInfinity('1');

    altfmaxfmin = FALSE;    // Restrict use of FMAX/FMIN NaN propagation rules
    result = FPMax(op1, op2, fpcr, altfmaxfmin);

    return result;
```

## Library pseudocode for shared/functions/float/fpmerge/IsMerging

```
// IsMerging()
// =====
// Returns TRUE if the output elements other than the lowest are taken from
// the destination register.

boolean IsMerging(FPCRTType fpcr)
    boolean merge = HaveAltFP() && !UsingAArch32() && fpcr.NEP == '1';
    return merge;
```

## Library pseudocode for shared/functions/float/fpmin/FPMin

```
// FPMin()
// =====

bits(N) FPMin(bits(N) op1, bits(N) op2, FPCRTType fpcr)
    boolean altfp = HaveAltFP() && !UsingAArch32() && fpcr.AH == '1';
    return FPMIn(op1, op2, fpcr, altfp);

// FPMin()
// =====
// Compare two operands and return the smaller operand after rounding. The
// 'fpcr' argument supplies the FPCR control bits and 'altfp' determines
// if the function should use alternative behaviour.

bits(N) FPMin(bits(N) op1, bits(N) op2, FPCRTType fpcr, boolean altfp)

    assert N IN {16,32,64};
    (type1,sign1,value1) = FPUnpack(op1, fpcr);
    (type2,sign2,value2) = FPUnpack(op2, fpcr);

    if (altfp && type1 == FPTYPE\_Zero && type2 == FPTYPE\_Zero &&
        ((sign1 == '0' && sign2 == '1') || (sign1 == '1' && sign2 == '0'))) then
        return FPZero(sign2);

    (done,result) = FPProcessNaNs(type1, type2, op1, op2, fpcr, altfp, TRUE);

    if !done then
        if value1 < value2 then
            (ftype,sign,value) = (type1,sign1,value1);
        else
            (ftype,sign,value) = (type2,sign2,value2);
        if ftype == FPTYPE\_Infinity then
            result = FPInfinity(sign);
        elsif ftype == FPTYPE\_Zero then
            sign = sign1 OR sign2;           // Use most negative sign
            result = FPZero(sign);
        else
            // The use of FPRound() covers the case where there is a trapped underflow exception
            // for a denormalized number even though the result is exact.
            rounding = FPRoundingMode(fpcr);
            if altfp then // Denormal output is not flushed to zero
                fpcr.FZ = '0';
                fpcr.FZ16 = '0';

            result = FPRound(value, fpcr, rounding, TRUE);

    FPProcessDenorms(type1, type2, N, fpcr);

    return result;
```

## Library pseudocode for shared/functions/float/fpminnum/FPMinNum

```
// FPMinNum()
// =====

bits(N) FPMinNum(bits(N) op1, bits(N) op2, FPCRTType fpcr)

    assert N IN {16,32,64};
    (type1,-,-) = FPUnpack(op1, fpcr);
    (type2,-,-) = FPUnpack(op2, fpcr);

    boolean type1_nan = type1 IN {FPTType\_QNaN, FPTType\_SNaN};
    boolean type2_nan = type2 IN {FPTType\_QNaN, FPTType\_SNaN};
    boolean altfp = HaveAltFP() && !UsingAArch32() && fpcr.AH == '1';

    if !(altfp && type1_nan && type2_nan) then
        // Treat a single quiet-NaN as +Infinity.
        if type1 == FPTType\_QNaN && type2 != FPTType\_QNaN then
            op1 = FPInfinity('0');
        elsif type1 != FPTType\_QNaN && type2 == FPTType\_QNaN then
            op2 = FPInfinity('0');

    altfmaxfmin = FALSE;    // Restrict use of FMAX/FMIN NaN propagation rules
    result = FPMIn(op1, op2, fpcr, altfmaxfmin);

    return result;
```

## Library pseudocode for shared/functions/float/fpmul/FPMul

```
// FPMul()
// =====

bits(N) FPMul(bits(N) op1, bits(N) op2, FPCRTType fpcr)

    assert N IN {16,32,64};
    (type1,sign1,value1) = FPUnpack(op1, fpcr);
    (type2,sign2,value2) = FPUnpack(op2, fpcr);
    (done,result) = FPProcessNaNs(type1, type2, op1, op2, fpcr);
    if !done then
        inf1 = (type1 == FPTType\_Infinity);
        inf2 = (type2 == FPTType\_Infinity);
        zero1 = (type1 == FPTType\_Zero);
        zero2 = (type2 == FPTType\_Zero);

        if (inf1 && zero2) || (zero1 && inf2) then
            result = FPDefaultNaN(fpcr);
            FPProcessException(FPExc\_InvalidOp, fpcr);
        elsif inf1 || inf2 then
            result = FPInfinity(sign1 EOR sign2);
        elsif zero1 || zero2 then
            result = FPZero(sign1 EOR sign2);
        else
            result = FPRound(value1*value2, fpcr);

            FPProcessDenorms(type1, type2, N, fpcr);

    return result;
```





```

// FPMulAdd()
// =====

bits(N) FPMulAdd(bits(N) addend, bits(N) op1, bits(N) op2, FPCRTType fpcr)
    boolean fpexc = TRUE;          // Generate floating-point exceptions
    return FPMulAdd(addend, op1, op2, fpcr, fpexc);

// FPMulAdd()
// =====
//
// Calculates addend + op1*op2 with a single rounding. The 'fpcr' argument
// supplies the FPCR control bits, and 'fpexc' controls the generation of
// floating-point exceptions.

bits(N) FPMulAdd(bits(N) addend, bits(N) op1, bits(N) op2,
    FPCRTType fpcr, boolean fpexc)

    assert N IN {16,32,64};

    (typeA,signA,valueA) = FPUunpack(addend, fpcr, fpexc);
    (type1,sign1,value1) = FPUunpack(op1, fpcr, fpexc);
    (type2,sign2,value2) = FPUunpack(op2, fpcr, fpexc);
    rounding = FPRoundingMode(fpcr);
    inf1 = (type1 == FPTYPE\_Infinity); zero1 = (type1 == FPTYPE\_Zero);
    inf2 = (type2 == FPTYPE\_Infinity); zero2 = (type2 == FPTYPE\_Zero);

    (done,result) = FPProcessNaNs3(typeA, type1, type2, addend, op1, op2, fpcr, fpexc);

    if !(HaveAltFP() && UsingAArch32() && fpcr.AH == '1') then
        if typeA == FPTYPE\_0NaN && ((inf1 && zero2) || (zero1 && inf2)) then
            result = FPDefaultNaN(fpcr);
            if fpexc then FPProcessException(FPExc\_InvalidOp, fpcr);

    if !done then
        infA = (typeA == FPTYPE\_Infinity); zeroA = (typeA == FPTYPE\_Zero);

        // Determine sign and type product will have if it does not cause an
        // Invalid Operation.
        signP = sign1 EOR sign2;
        infP = inf1 || inf2;
        zeroP = zero1 || zero2;

        // Non SNaN-generated Invalid Operation cases are multiplies of zero
        // by infinity and additions of opposite-signed infinities.
        invalidop = (inf1 && zero2) || (zero1 && inf2) || (infA && infP && signA != signP);

        if invalidop then
            result = FPDefaultNaN(fpcr);
            if fpexc then FPProcessException(FPExc\_InvalidOp, fpcr);
            // Other cases involving infinities produce an infinity of the same sign.
        elsif (infA && signA == '0') || (infP && signP == '0') then
            result = FPIfinity('0');
        elsif (infA && signA == '1') || (infP && signP == '1') then
            result = FPIfinity('1');

        // Cases where the result is exactly zero and its sign is not determined by the
        // rounding mode are additions of same-signed zeros.
        elsif zeroA && zeroP && signA == signP then
            result = FPZero(signA);

        // Otherwise calculate numerical result and round it.
        else
            result_value = valueA + (value1 * value2);
            if result_value == 0.0 then // Sign of exact zero result depends on rounding mode
                result_sign = if rounding == FPRounding\_NEGINF then '1' else '0';
                result = FPZero(result_sign);
            else
                result = FPRound(result_value, fpcr, rounding, fpexc);

    if !invalidop && fpexc then

```

```

        FPProcessDenorms3(typeA, type1, type2, N, fpcr);

return result;

```

## Library pseudocode for shared/functions/float/fpmuladdh/FPMulAddH

```

// FPMulAddH()
// =====
// Calculates addend + op1*op2.

bits(N) FPMulAddH(bits(N) addend, bits(N DIV 2) op1, bits(N DIV 2) op2, FPCRTType fpcr)

    assert N == 32;
    rounding = FPRoundingMode(fpcr);
    (typeA,signA,valueA) = FPUnpack(addend, fpcr);
    (type1,sign1,value1) = FPUnpack(op1, fpcr);
    (type2,sign2,value2) = FPUnpack(op2, fpcr);
    inf1 = (type1 == FPTType\_Infinity); zero1 = (type1 == FPTType\_Zero);
    inf2 = (type2 == FPTType\_Infinity); zero2 = (type2 == FPTType\_Zero);
    (done,result) = FPProcessNaNs3H(typeA, type1, type2, addend, op1, op2, fpcr);

    if !(HaveAltFP() && !UsingAArch32() && fpcr.AH == '1') then
        if typeA == FPTType\_QNaN && ((inf1 && zero2) || (zero1 && inf2)) then
            result = FPDefaultNaN(fpcr);
            FPProcessException(FPExc\_InvalidOp, fpcr);

    if !done then
        infA = (typeA == FPTType\_Infinity); zeroA = (typeA == FPTType\_Zero);

        // Determine sign and type product will have if it does not cause an
        // Invalid Operation.
        signP = sign1 EOR sign2;
        infP = inf1 || inf2;
        zeroP = zero1 || zero2;

        // Non SNaN-generated Invalid Operation cases are multiplies of zero by infinity and
        // additions of opposite-signed infinities.
        invalidop = (inf1 && zero2) || (zero1 && inf2) || (infA && infP && signA != signP);

        if invalidop then
            result = FPDefaultNaN(fpcr);
            FPProcessException(FPExc\_InvalidOp, fpcr);

        // Other cases involving infinities produce an infinity of the same sign.
        elsif (infA && signA == '0') || (infP && signP == '0') then
            result = FPInfinity('0');
        elsif (infA && signA == '1') || (infP && signP == '1') then
            result = FPInfinity('1');

        // Cases where the result is exactly zero and its sign is not determined by the
        // rounding mode are additions of same-signed zeros.
        elsif zeroA && zeroP && signA == signP then
            result = FPZero(signA);

        // Otherwise calculate numerical result and round it.
        else
            result_value = valueA + (value1 * value2);
            if result_value == 0.0 then // Sign of exact zero result depends on rounding mode
                result_sign = if rounding == FPRounding\_NEGINF then '1' else '0';
                result = FPZero(result_sign);
            else
                result = FPRound(result_value, fpcr);

        if !invalidop then
            FPProcessDenorm(typeA, N, fpcr);

return result;

```

## Library pseudocode for shared/functions/float/fpmuladdh/FPPProcessNaNs3H

```
// FPPProcessNaNs3H()
// =====

(boolean, bits(N)) FPPProcessNaNs3H(FPTYPE type1, FPTYPE type2, FPTYPE type3,
                                   bits(N) op1, bits(N DIV 2) op2, bits(N DIV 2) op3,
                                   FPCRTYPE fpcr)

    assert N IN {32,64};

    bits(N) result;
    // When TRUE, use alternative NaN propagation rules.
    boolean altfp = HaveAltFP() && !UsingAArch32() && fpcr.AH == '1';
    boolean op1_nan = type1 IN {FPTYPE\_SNaN, FPTYPE\_QNaN};
    boolean op2_nan = type2 IN {FPTYPE\_SNaN, FPTYPE\_QNaN};
    boolean op3_nan = type3 IN {FPTYPE\_SNaN, FPTYPE\_QNaN};
    boolean fpexc = TRUE;
    if altfp then
        if (type1 == FPTYPE\_SNaN || type2 == FPTYPE\_SNaN || type3 == FPTYPE\_SNaN) then
            type_nan = FPTYPE\_SNaN;
        else
            type_nan = FPTYPE\_QNaN;

    if altfp && op1_nan && op2_nan && op3_nan then
        done = TRUE; result = FPConvertNaN(FPPProcessNaN(type_nan, op2, fpcr, fpexc)); // <n> register
    elsif altfp && op2_nan && (op1_nan || op3_nan) then
        done = TRUE; result = FPConvertNaN(FPPProcessNaN(type_nan, op2, fpcr, fpexc)); // <n> register
    elsif altfp && op3_nan && op1_nan then
        done = TRUE; result = FPConvertNaN(FPPProcessNaN(type_nan, op3, fpcr, fpexc)); // <m> register
    elsif type1 == FPTYPE\_SNaN then
        done = TRUE; result = FPPProcessNaN(type1, op1, fpcr, fpexc);
    elsif type2 == FPTYPE\_SNaN then
        done = TRUE; result = FPConvertNaN(FPPProcessNaN(type2, op2, fpcr, fpexc));
    elsif type3 == FPTYPE\_SNaN then
        done = TRUE; result = FPConvertNaN(FPPProcessNaN(type3, op3, fpcr, fpexc));
    elsif type1 == FPTYPE\_QNaN then
        done = TRUE; result = FPPProcessNaN(type1, op1, fpcr, fpexc);
    elsif type2 == FPTYPE\_QNaN then
        done = TRUE; result = FPConvertNaN(FPPProcessNaN(type2, op2, fpcr, fpexc));
    elsif type3 == FPTYPE\_QNaN then
        done = TRUE; result = FPConvertNaN(FPPProcessNaN(type3, op3, fpcr, fpexc));
    else
        done = FALSE; result = Zeros(); // 'Don't care' result
    return (done, result);
```

## Library pseudocode for shared/functions/float/fpmulx/FPMulX

```
// FPMulX()
// =====

bits(N) FPMulX(bits(N) op1, bits(N) op2, FPCRTType fpcr)

    assert N IN {16,32,64};
    bits(N) result;
    (type1,sign1,value1) = FPUnpack(op1, fpcr);
    (type2,sign2,value2) = FPUnpack(op2, fpcr);

    (done,result) = FPProcessNaNs(type1, type2, op1, op2, fpcr);
    if !done then
        inf1 = (type1 == FPTType\_Infinity);
        inf2 = (type2 == FPTType\_Infinity);
        zero1 = (type1 == FPTType\_Zero);
        zero2 = (type2 == FPTType\_Zero);

        if (inf1 && zero2) || (zero1 && inf2) then
            result = FPTwo(sign1 EOR sign2);
        elsif inf1 || inf2 then
            result = FPIInfinity(sign1 EOR sign2);
        elsif zero1 || zero2 then
            result = FPZero(sign1 EOR sign2);
        else
            result = FPRound(value1*value2, fpcr);

            FPProcessDenorms(type1, type2, N, fpcr);

    return result;
```

## Library pseudocode for shared/functions/float/fpneg/FPNeg

```
// FPNeg()
// =====

bits(N) FPNeg(bits(N) op)

    assert N IN {16,32,64};
    if !UsingAArch32() && HaveAltFP() then
        FPCRTType fpcr = FPCR[];
        if fpcr.AH == '1' then
            (fptype, -, -) = FPUnpack(op, fpcr, FALSE);
            if fptype IN {FPTType\_SNaN, FPType\_QNaN} then

                return op;          // When fpcr.AH=1, sign of NaN has no consequence

    return NOT(op<N-1>) : op<N-2:0>;
```

## Library pseudocode for shared/functions/float/fponepointfive/FPOnePointFive

```
// FPOnePointFive()
// =====

bits(N) FPOnePointFive(bit sign)

    assert N IN {16,32,64};
    constant integer E = (if N == 16 then 5 elsif N == 32 then 8 else 11);
    constant integer F = N - (E + 1);
    exp = '0':Ones(E-1);
    frac = '1':Zeros(F-1);
    result = sign : exp : frac;

    return result;
```

### Library pseudocode for shared/functions/float/fpprocessdenorms/FPPProcessDenorm

```
// FPPProcessDenorm()
// =====
// Handles denormal input in case of single-precision or double-precision
// when using alternative floating-point mode.

FPPProcessDenorm(FPType fptype, integer N, FPCRTType fpcr)
    boolean altfp = HaveAltFP() && !UsingAArch32() && fpcr.AH == '1';
    if altfp && N != 16 && fptype == FPType_Denormal then
        FPPProcessException(FPExc_InputDenorm, fpcr);
```

### Library pseudocode for shared/functions/float/fpprocessdenorms/FPPProcessDenorms

```
// FPPProcessDenorms()
// =====
// Handles denormal input in case of single-precision or double-precision
// when using alternative floating-point mode.

FPPProcessDenorms(FPType type1, FPType type2, integer N, FPCRTType fpcr)
    boolean altfp = HaveAltFP() && !UsingAArch32() && fpcr.AH == '1';
    if altfp && N != 16 && (type1 == FPType_Denormal || type2 == FPType_Denormal) then
        FPPProcessException(FPExc_InputDenorm, fpcr);
```

### Library pseudocode for shared/functions/float/fpprocessdenorms/FPPProcessDenorms3

```
// FPPProcessDenorms3()
// =====
// Handles denormal input in case of single-precision or double-precision
// when using alternative floating-point mode.

FPPProcessDenorms3(FPType type1, FPType type2, FPType type3, integer N, FPCRTType fpcr)
    boolean altfp = HaveAltFP() && !UsingAArch32() && fpcr.AH == '1';
    if altfp && N != 16 && (type1 == FPType_Denormal || type2 == FPType_Denormal ||
        type3 == FPType_Denormal) then
        FPPProcessException(FPExc_InputDenorm, fpcr);
```

## Library pseudocode for shared/functions/float/fpprocessexception/FPProcessException

```
// FPProcessException()
// =====
//
// The 'fpcr' argument supplies FPCR control bits. Status information is
// updated directly in the FPSR where appropriate.

FPProcessException(FPExc exception, FPCRTYPE fpcr)

// Determine the cumulative exception bit number
case exception of
    when FPExc_InvalidOp      cumul = 0;
    when FPExc_DivideByZero   cumul = 1;
    when FPExc_Overflow       cumul = 2;
    when FPExc_Underflow      cumul = 3;
    when FPExc_Inexact        cumul = 4;
    when FPExc_InputDenorm    cumul = 7;
enable = cumul + 8;
if fpcr<enable> == '1' then
    // Trapping of the exception enabled.
    // It is IMPLEMENTATION DEFINED whether the enable bit may be set at all, and
    // if so then how exceptions may be accumulated before calling FPTrappedException()
    IMPLEMENTATION_DEFINED "floating-point trap handling";
elsif UsingAArch32() then
    // Set the cumulative exception bit
    FPSCR<cumul> = '1';
else
    // Set the cumulative exception bit
    FPSR<cumul> = '1';

return;
```

## Library pseudocode for shared/functions/float/fpprocessnan/FPProcessNaN

```
// FPProcessNaN()
// =====
bits(N) FPProcessNaN(FPTYPE fptype, bits(N) op, FPCRTYPE fpcr)
    boolean fpexc = TRUE; // Generate floating-point exceptions
    return FPProcessNaN(fptype, op, fpcr, fpexc);

// FPProcessNaN()
// =====
// Handle NaN input operands, returning the operand or default NaN value
// if fpcr.DN is selected. The 'fpcr' argument supplies the FPCR control bits.
// The 'fpexc' argument controls the generation of exceptions, regardless of
// whether 'fptype' is a signalling NaN or a quiet NaN.

bits(N) FPProcessNaN(FPTYPE fptype, bits(N) op, FPCRTYPE fpcr, boolean fpexc)

    assert N IN {16,32,64};
    assert fptype IN {FPTYPE_0NaN, FPTYPE_SNaN};

    case N of
        when 16 topfrac = 9;
        when 32 topfrac = 22;
        when 64 topfrac = 51;

    result = op;
    if fptype == FPTYPE_SNaN then
        result<topfrac> = '1';
        if fpexc then FPProcessException(FPExc_InvalidOp, fpcr);
    if fpcr.DN == '1' then // DefaultNaN requested
        result = FPDefaultNaN(fpcr);

    return result;
```

## Library pseudocode for shared/functions/float/fpprocessnans/FPProcessNaNs

```
// FPProcessNaNs()
// =====

(boolean, bits(N)) FPProcessNaNs(FPType type1, FPType type2, bits(N) op1,
                                bits(N) op2, FPCRType fpcr)
    boolean altfmaxfmin = FALSE;    // Do not use alfp mode for FMIN, FMAX and variants
    boolean fpexc       = TRUE;     // Generate floating-point exceptions
    return FPProcessNaNs(type1, type2, op1, op2, fpcr, altfmaxfmin, fpexc);

// FPProcessNaNs()
// =====
//
// The boolean part of the return value says whether a NaN has been found and
// processed. The bits(N) part is only relevant if it has and supplies the
// result of the operation.
//
// The 'fpcr' argument supplies FPCR control bits and 'altfmaxfmin' controls
// alternative floating-point behaviour for FMAX, FMIN and variants. 'fpexc'
// controls the generation of floating-point exceptions. Status information
// is updated directly in the FPSR where appropriate.

(boolean, bits(N)) FPProcessNaNs(FPType type1, FPType type2, bits(N) op1, bits(N) op2,
                                FPCRType fpcr, boolean altfmaxfmin, boolean fpexc)

    assert N IN {16,32,64};
    boolean altfp      = HaveAltFP() && !UsingAArch32() && fpcr.AH == '1';
    boolean op1_nan    = type1 IN {FPType_SNaN, FPType_QNaN};
    boolean op2_nan    = type2 IN {FPType_SNaN, FPType_QNaN};
    boolean any_snan   = type1 == FPType_SNaN || type2 == FPType_SNaN;
    FPType type_nan    = if any_snan then FPType_SNaN else FPType_QNaN;

    if altfmaxfmin && (op1_nan || op2_nan) then
        FPProcessException(FPExc_InvalidOp, fpcr);
        done = TRUE; sign2 = op2<N-1>;
        result = if type2 == FPType_Zero then FPZero(sign2) else op2;
    elsif altfp && op1_nan && op2_nan then
        done = TRUE; result = FPProcessNaN(type_nan, op1, fpcr, fpexc);    // <n> register NaN selected
    elsif type1 == FPType_SNaN then
        done = TRUE; result = FPProcessNaN(type1, op1, fpcr, fpexc);
    elsif type2 == FPType_SNaN then
        done = TRUE; result = FPProcessNaN(type2, op2, fpcr, fpexc);
    elsif type1 == FPType_QNaN then
        done = TRUE; result = FPProcessNaN(type1, op1, fpcr, fpexc);
    elsif type2 == FPType_QNaN then
        done = TRUE; result = FPProcessNaN(type2, op2, fpcr, fpexc);
    else
        done = FALSE; result = Zeros();    // 'Don't care' result

    return (done, result);
```

## Library pseudocode for shared/functions/float/fpprocessnans3/FPPProcessNaNs3

```
// FPPProcessNaNs3()
// =====

(boolean, bits(N)) FPPProcessNaNs3(FPType type1, FPType type2, FPType type3,
                                   bits(N) op1, bits(N) op2, bits(N) op3,
                                   FPCRTType fpcr)
    boolean fpexc = TRUE;    // Generate floating-point exceptions
    return FPPProcessNaNs3(type1, type2, type3, op1, op2, op3, fpcr, fpexc);

// FPPProcessNaNs3()
// =====
// The boolean part of the return value says whether a NaN has been found and
// processed. The bits(N) part is only relevant if it has and supplies the
// result of the operation.
//
// The 'fpcr' argument supplies FPCR control bits and 'fpexc' controls the
// generation of floating-point exceptions. Status information is updated
// directly in the FPSR where appropriate.

(boolean, bits(N)) FPPProcessNaNs3(FPType type1, FPType type2, FPType type3,
                                   bits(N) op1, bits(N) op2, bits(N) op3,
                                   FPCRTType fpcr, boolean fpexc)

    assert N IN {16,32,64};
    boolean op1_nan = type1 IN {FPType_SNaN, FPType_QNaN};
    boolean op2_nan = type2 IN {FPType_SNaN, FPType_QNaN};
    boolean op3_nan = type3 IN {FPType_SNaN, FPType_QNaN};

    boolean altfp = HaveAltFP() && !UsingAArch32() && fpcr.AH == '1';
    if altfp then
        if type1 == FPType_SNaN || type2 == FPType_SNaN || type3 == FPType_SNaN then
            type_nan = FPType_SNaN;
        else
            type_nan = FPType_QNaN;

    if altfp && op1_nan && op2_nan && op3_nan then
        done = TRUE; result = FPPProcessNaN(type_nan, op2, fpcr, fpexc);    // <n> register NaN selected
    elsif altfp && op2_nan && (op1_nan || op3_nan) then
        done = TRUE; result = FPPProcessNaN(type_nan, op2, fpcr, fpexc);    // <n> register NaN selected
    elsif altfp && op3_nan && op1_nan then
        done = TRUE; result = FPPProcessNaN(type_nan, op3, fpcr, fpexc);    // <m> register NaN selected
    elsif type1 == FPType_SNaN then
        done = TRUE; result = FPPProcessNaN(type1, op1, fpcr, fpexc);
    elsif type2 == FPType_SNaN then
        done = TRUE; result = FPPProcessNaN(type2, op2, fpcr, fpexc);
    elsif type3 == FPType_SNaN then
        done = TRUE; result = FPPProcessNaN(type3, op3, fpcr, fpexc);
    elsif type1 == FPType_QNaN then
        done = TRUE; result = FPPProcessNaN(type1, op1, fpcr, fpexc);
    elsif type2 == FPType_QNaN then
        done = TRUE; result = FPPProcessNaN(type2, op2, fpcr, fpexc);
    elsif type3 == FPType_QNaN then
        done = TRUE; result = FPPProcessNaN(type3, op3, fpcr, fpexc);
    else
        done = FALSE; result = Zeros();    // 'Don't care' result

    return (done, result);
```





```

// FPRecipEstimate()
// =====

bits(N) FPRecipEstimate(bits(N) operand, FPCRTType fpcr)

    assert N IN {16,32,64};

    // When using alternative floating-point behaviour, do not generate
    // floating-point exceptions, flush denormal input and output to zero,
    // and use RNE rounding mode.
    boolean altfp = HaveAltFP() && !UsingAArch32() && fpcr.AH == '1';
    boolean fpexc = !altfp;
    if altfp then fpcr.<FIZ,FZ> = '11';
    if altfp then fpcr.RMode = '00';

    (fptype,sign,value) = FPUnpack(operand, fpcr, fpexc);

    FPRounding rounding = FPRoundingMode(fpcr);
    if fptype == FPTType\_SNaN || fptype == FPTType\_QNaN then
        result = FPProcessNaN(fptype, operand, fpcr, fpexc);
    elsif fptype == FPTType\_Infinity then
        result = FPZero(sign);
    elsif fptype == FPTType\_Zero then
        result = FPInfinity(sign);
        if fpexc then FPProcessException(FPExc\_DivideByZero, fpcr);
    elsif (
        (N == 16 && Abs(value) < 2.0^-16) ||
        (N == 32 && Abs(value) < 2.0^-128) ||
        (N == 64 && Abs(value) < 2.0^-1024)
    ) then
        case rounding of
            when FPRounding\_TIEEVEN
                overflow_to_inf = TRUE;
            when FPRounding\_POSINF
                overflow_to_inf = (sign == '0');
            when FPRounding\_NEGINF
                overflow_to_inf = (sign == '1');
            when FPRounding\_ZERO
                overflow_to_inf = FALSE;
        result = if overflow_to_inf then FPInfinity(sign) else FPMMaxNormal(sign);
    if fpexc then
        FPProcessException(FPExc\_Overflow, fpcr);
        FPProcessException(FPExc\_Inexact, fpcr);
    elsif ((fpcr.FZ == '1' && N != 16) || (fpcr.FZ16 == '1' && N == 16))
        && (
            (N == 16 && Abs(value) >= 2.0^14) ||
            (N == 32 && Abs(value) >= 2.0^126) ||
            (N == 64 && Abs(value) >= 2.0^1022)
        ) then
        // Result flushed to zero of correct sign
        result = FPZero(sign);

        // Flush-to-zero never generates a trapped exception.
        if UsingAArch32() then
            FPSCR.UFC = '1';
        else
            if fpexc then FPSR.UFC = '1';
    else
        // Scale to a fixed point value in the range 0.5 <= x < 1.0 in steps of 1/512, and
        // calculate result exponent. Scaled value has copied sign bit,
        // exponent = 1022 = double-precision biased version of -1,
        // fraction = original fraction
        case N of
            when 16
                fraction = operand<9:0> : Zeros(42);
                exp = UInt(operand<14:10>);
            when 32
                fraction = operand<22:0> : Zeros(29);
                exp = UInt(operand<30:23>);
            when 64

```

```

        fraction = operand<51:0>;
        exp = UInt(operand<62:52>);

if exp == 0 then
    if fraction<51> == '0' then
        exp = -1;
        fraction = fraction<49:0>:'00';
    else
        fraction = fraction<50:0>:'0';

integer scaled;
boolean increasedprecision = N==32 && HaveFeatRPRES() && altfp;

if !increasedprecision then
    scaled = UInt('1':fraction<51:44>);
else
    scaled = UInt('1':fraction<51:41>);

case N of
    when 16 result_exp = 29 - exp; // In range 29-30 = -1 to 29+1 = 30
    when 32 result_exp = 253 - exp; // In range 253-254 = -1 to 253+1 = 254
    when 64 result_exp = 2045 - exp; // In range 2045-2046 = -1 to 2045+1 = 2046

// Scaled is in range 256 .. 511 or 2048 .. 4095 range representing a
// fixed-point number in range [0.5 .. 1.0].
estimate = RecipEstimate(scaled, increasedprecision);

// Estimate is in the range 256 .. 511 or 4096 .. 8191 representing a
// fixed-point result in the range [1.0 .. 2.0].
// Convert to scaled floating point result with copied sign bit,
// high-order bits from estimate, and exponent calculated above.
if !increasedprecision then
    fraction = estimate<7:0> : Zeros(44);
else
    fraction = estimate<11:0> : Zeros(40);

if result_exp == 0 then
    fraction = '1' : fraction<51:1>;
elsif result_exp == -1 then
    fraction = '01' : fraction<51:2>;
    result_exp = 0;

case N of
    when 16 result = sign : result_exp<N-12:0> : fraction<51:42>;
    when 32 result = sign : result_exp<N-25:0> : fraction<51:29>;
    when 64 result = sign : result_exp<N-54:0> : fraction<51:0>;

return result;

```

## Library pseudocode for shared/functions/float/fpreciestimate/RecipEstimate

```
// RecipEstimate()
// =====
// Compute estimate of reciprocal of 9-bit fixed-point number.
//
// a is in range 256 .. 511 or 2048 .. 4096 representing a number in
// the range  $0.5 \leq x < 1.0$ .
// increasedprecision determines if the mantissa is 8-bit or 12-bit.
// result is in the range 256 .. 511 or 4096 .. 8191 representing a
// number in the range 1.0 to 511/256 or 1.00 to 8191/4096.

integer RecipEstimate(integer a, boolean increasedprecision)

    integer r;
    if !increasedprecision then
        assert 256 <= a && a < 512;
        a = a*2+1; // Round to nearest
        integer b = (2 ^ 19) DIV a;
        r = (b+1) DIV 2; // Round to nearest
        assert 256 <= r && r < 512;
    else
        assert 2048 <= a && a < 4096;
        a = a*2+1; // Round to nearest
        real real_val = Real(2^25)/Real(a);
        r = RoundDown(real_val);
        real error = real_val - Real(r);
        boolean round_up = error > 0.5; // Error cannot be exactly 0.5 so do not need tie case
        if round_up then r = r+1;
        assert 4096 <= r && r < 8192;

    return r;
```

## Library pseudocode for shared/functions/float/fprecpX/FPRecpX

```
// FPRecpX()
// =====

bits(N) FPRecpX(bits(N) op, FPCRTType fpcr)

    assert N IN {16,32,64};

    case N of
        when 16 esize = 5;
        when 32 esize = 8;
        when 64 esize = 11;

    bits(N)          result;
    bits(esize)      exp;
    bits(esize)      max_exp;
    bits(N-(esize+1)) frac = Zeros();

    boolean altfp = HaveAltFP() && fpcr.AH == '1';
    boolean fpexc = !altfp;           // Generate no floating-point exceptions
    if altfp then fpcr.<FIZ,FZ> = '11'; // Flush denormal input and output to zero
    (fptype,sign,value) = FPUntpack(op, fpcr, fpexc);

    case N of
        when 16 exp = op<10+esize-1:10>;
        when 32 exp = op<23+esize-1:23>;
        when 64 exp = op<52+esize-1:52>;

    max_exp = Ones(esize) - 1;

    if fptype == FType\_SNaN || fptype == FType\_QNaN then
        result = FPProcessNaN(fptype, op, fpcr, fpexc);
    else
        if IsZero(exp) then           // Zero and denormals
            result = sign:max_exp:frac;
        else                          // Infinities and normals
            result = sign:NOT(exp):frac;

    return result;
```

## Library pseudocode for shared/functions/float/fpround/FPRound

```
// FPRound()
// =====
// Used by data processing and int/fixed <-> FP conversion instructions.
// For half-precision data it ignores AHP, and observes FZ16.

bits(N) FPRound(real op, FPCRTType fpcr, FPRounding rounding)
    fpcr.AHP = '0';
    boolean fpexc = TRUE;    // Generate floating-point exceptions
    boolean isbfloat16 = FALSE;
    return FPRoundBase(op, fpcr, rounding, isbfloat16, fpexc);

// FPRound()
// =====
// Used by data processing and int/fixed <-> FP conversion instructions.
// For half-precision data it ignores AHP, and observes FZ16.
//
// The 'fpcr' argument supplies FPCR control bits and 'fpexc' controls the
// generation of floating-point exceptions. Status information is updated
// directly in the FPSR where appropriate.

bits(N) FPRound(real op, FPCRTType fpcr, FPRounding rounding, boolean fpexc)
    fpcr.AHP = '0';
    boolean isbfloat16 = FALSE;
    return FPRoundBase(op, fpcr, rounding, isbfloat16, fpexc);

// FPRound()
// =====

bits(N) FPRound(real op, FPCRTType fpcr)
    return FPRound(op, fpcr, FPRoundingMode(fpcr));
```



```

// FPRoundBase()
// =====

bits(N) FPRoundBase(real op, FPCRTType fpcr, FPRounding rounding, boolean isbfloat16)
    boolean fpexc = TRUE;    // Generate floating-point exceptions
    return FPRoundBase(op, fpcr, rounding, isbfloat16, fpexc);

// FPRoundBase()
// =====
// Convert a real number OP into an N-bit floating-point value using the
// supplied rounding mode RMODE.
//
// The 'fpcr' argument supplies FPCR control bits and 'fpexc' controls the
// generation of floating-point exceptions. Status information is updated
// directly in the FPSR where appropriate.

bits(N) FPRoundBase(real op, FPCRTType fpcr, FPRounding rounding,
    boolean isbfloat16, boolean fpexc)

    assert N IN {16,32,64};
    assert op != 0.0;
    assert rounding != FPRounding\_TIEAWAY;
    bits(N) result;

    // Obtain format parameters - minimum exponent, numbers of exponent and fraction bits.
    if N == 16 then
        minimum_exp = -14; E = 5; F = 10;
    elseif N == 32 && isbfloat16 then
        minimum_exp = -126; E = 8; F = 7;
    elseif N == 32 then
        minimum_exp = -126; E = 8; F = 23;
    else // N == 64
        minimum_exp = -1022; E = 11; F = 52;

    // Split value into sign, unrounded mantissa and exponent.
    if op < 0.0 then
        sign = '1'; mantissa = -op;
    else
        sign = '0'; mantissa = op;
    exponent = 0;
    while mantissa < 1.0 do
        mantissa = mantissa * 2.0; exponent = exponent - 1;
    while mantissa >= 2.0 do
        mantissa = mantissa / 2.0; exponent = exponent + 1;

    // When TRUE, detection of underflow occurs after rounding and the test for a
    // denormalized number for single and double precision values occurs after rounding.
    altfp = HaveAltFP() && !UsingAArch32() && fpcr.AH == '1';

    // Deal with flush-to-zero before rounding if FPCR.AH != '1'.
    if (!altfp && ((fpcr.FZ == '1' && N != 16) || (fpcr.FZ16 == '1' && N == 16)) &&
        exponent < minimum_exp) then
        // Flush-to-zero never generates a trapped exception.
        if UsingAArch32() then
            FPSR.UFC = '1';
        else
            FPSR.UFC = '1';
        return FPZero(sign);

    biased_exp_unconstrained = exponent - minimum_exp + 1;
    int_mant_unconstrained = RoundDown(mantissa * 2.0^F);
    error_unconstrained = mantissa * 2.0^F - Real(int_mant_unconstrained);

    // Start creating the exponent value for the result. Start by biasing the actual exponent
    // so that the minimum exponent becomes 1, lower values 0 (indicating possible underflow).
    biased_exp = Max(exponent - minimum_exp + 1, 0);
    if biased_exp == 0 then mantissa = mantissa / 2.0^(minimum_exp - exponent);

    // Get the unrounded mantissa as an integer, and the "units in last place" rounding error.
    int_mant = RoundDown(mantissa * 2.0^F); // < 2.0^F if biased_exp == 0, >= 2.0^F if not

```



```

error = mantissa * 2.0^F - Real(int_mant);

// Underflow occurs if exponent is too small before rounding, and result is inexact or
// the Underflow exception is trapped. This applies before rounding if FPCR.AH != '1'.
if !altfp && biased_exp == 0 && (error != 0.0 || fpcr.UFE == '1') then
    if fpexc then FPProcessException\(FPExc\_Underflow, fpcr);

// Round result according to rounding mode.
if altfp then
    case rounding of
        when FPRounding\_TIEEVEN
            round_up_unconstrained = (error_unconstrained > 0.5 ||
                (error_unconstrained == 0.5 && int_mant_unconstrained<0> == '1'));
            round_up = (error > 0.5 || (error == 0.5 && int_mant<0> == '1'));
            overflow_to_inf = TRUE;
        when FPRounding\_POSINF
            round_up_unconstrained = (error_unconstrained != 0.0 && sign == '0');
            round_up = (error != 0.0 && sign == '0');
            overflow_to_inf = (sign == '0');
        when FPRounding\_NEGINF
            round_up_unconstrained = (error_unconstrained != 0.0 && sign == '1');
            round_up = (error != 0.0 && sign == '1');
            overflow_to_inf = (sign == '1');
        when FPRounding\_ZERO, FPRounding\_ODD
            round_up_unconstrained = FALSE;
            round_up = FALSE;
            overflow_to_inf = FALSE;

    if round_up_unconstrained then
        int_mant_unconstrained = int_mant_unconstrained + 1;
        if int_mant_unconstrained == 2^(F+1) then // Rounded up to next exponent
            biased_exp_unconstrained = biased_exp_unconstrained + 1;
            int_mant_unconstrained = int_mant_unconstrained DIV 2;

// Deal with flush-to-zero and underflow after rounding if FPCR.AH == '1'.
if biased_exp_unconstrained < 1 && int_mant_unconstrained != 0 then
    // the result of unconstrained rounding is less than the minimum normalized number
    if (fpcr.FZ == '1' && N != 16) || (fpcr.FZ16 == '1' && N == 16) then // Flush-to-zero
        if fpexc then
            FPSR.UFC = '1';
            FPProcessException\(FPExc\_Inexact, fpcr);
        return FPZero(sign);
    elseif error != 0.0 || fpcr.UFE == '1' then
        if fpexc then FPProcessException\(FPExc\_Underflow, fpcr);
else // altfp == FALSE
    case rounding of
        when FPRounding\_TIEEVEN
            round_up = (error > 0.5 || (error == 0.5 && int_mant<0> == '1'));
            overflow_to_inf = TRUE;
        when FPRounding\_POSINF
            round_up = (error != 0.0 && sign == '0');
            overflow_to_inf = (sign == '0');
        when FPRounding\_NEGINF
            round_up = (error != 0.0 && sign == '1');
            overflow_to_inf = (sign == '1');
        when FPRounding\_ZERO, FPRounding\_ODD
            round_up = FALSE;
            overflow_to_inf = FALSE;

    if round_up then
        int_mant = int_mant + 1;
        if int_mant == 2^F then // Rounded up from denormalized to normalized
            biased_exp = 1;
        if int_mant == 2^(F+1) then // Rounded up to next exponent
            biased_exp = biased_exp + 1;
            int_mant = int_mant DIV 2;

// Handle rounding to odd
if error != 0.0 && rounding == FPRounding\_ODD then
    int_mant<0> = '1';

```

```

// Deal with overflow and generate result.
if N != 16 || fpcr.AHP == '0' then // Single, double or IEEE half precision
  if biased_exp >= 2^E - 1 then
    result = if overflow_to_inf then FPInfinity(sign) else FPMMaxNormal(sign);
    if fpexc then FPPProcessException(FPExc\_Overflow, fpcr);
    error = 1.0; // Ensure that an Inexact exception occurs
  else
    result = sign : biased_exp<E-1:0> : int_mant<F-1:0> : Zeros(N-(E+F+1));
else
  // Alternative half precision
  if biased_exp >= 2^E then
    result = sign : Ones(N-1);
    if fpexc then FPPProcessException(FPExc\_InvalidOp, fpcr);
    error = 0.0; // Ensure that an Inexact exception does not occur
  else
    result = sign : biased_exp<E-1:0> : int_mant<F-1:0> : Zeros(N-(E+F+1));

// Deal with Inexact exception.
if error != 0.0 then
  if fpexc then FPPProcessException(FPExc\_Inexact, fpcr);

return result;

```

### Library pseudocode for shared/functions/float/fpround/FPRoundCV

```

// FPRoundCV()
// =====
// Used for FP <-> FP conversion instructions.
// For half-precision data ignores FZ16 and observes AHP.

bits(N) FPRoundCV(real op, FPCRTType fpcr, FPRounding rounding)
  fpcr.FZ16 = '0';
  boolean fpexc = TRUE; // Generate floating-point exceptions
  boolean isbfloat16 = FALSE;
  return FPRoundBase(op, fpcr, rounding, isbfloat16, fpexc);

```

### Library pseudocode for shared/functions/float/fprounding/FPRounding

```

enumeration FPRounding {FPRounding_TIEEVEN, FPRounding_POSINF,
                        FPRounding_NEGINF, FPRounding_ZERO,
                        FPRounding_TIEAWAY, FPRounding_ODD};

```

### Library pseudocode for shared/functions/float/fproundingmode/FPRoundingMode

```

// FPRoundingMode()
// =====
// Return the current floating-point rounding mode.

FPRounding FPRoundingMode(FPCRTType fpcr)
  return FPDecodeRounding(fpcr.RMode);

```

## Library pseudocode for shared/functions/float/fproundint/FPRoundInt

```
// FPRoundInt()
// =====

// Round op to nearest integral floating point value using rounding mode in FPCR/FPSR.
// If EXACT is TRUE, set FPSR.IXC if result is not numerically equal to op.

bits(N) FPRoundInt(bits(N) op, FPCRTYPE fpcr, FPRounding rounding, boolean exact)

    assert rounding != FPRounding\_ODD;
    assert N IN {16,32,64};

    // When alternative floating-point support is TRUE, do not generate
    // Input Denormal floating-point exceptions.
    altfp = HaveAltFP\(\) && !UsingAArch32\(\) && fpcr.AH == '1';
    fpexc = !altfp;

    // Unpack using FPCR to determine if subnormals are flushed-to-zero.
    (fptype,sign,value) = FPUntpack(op, fpcr, fpexc);

    if fptype == FPTYPE\_SNaN || fptype == FPTYPE\_QNaN then
        result = FPProcessNaN(fptype, op, fpcr);
    elseif fptype == FPTYPE\_Infinity then
        result = FPInfinity(sign);
    elseif fptype == FPTYPE\_Zero then
        result = FPZero(sign);
    else
        // Extract integer component.
        int_result = RoundDown(value);
        error = value - Real(int_result);

        // Determine whether supplied rounding mode requires an increment.
        case rounding of
            when FPRounding\_TIEEVEN
                round_up = (error > 0.5 || (error == 0.5 && int_result<0> == '1'));
            when FPRounding\_POSINF
                round_up = (error != 0.0);
            when FPRounding\_NEGINF
                round_up = FALSE;
            when FPRounding\_ZERO
                round_up = (error != 0.0 && int_result < 0);
            when FPRounding\_TIEAWAY
                round_up = (error > 0.5 || (error == 0.5 && int_result >= 0));

        if round_up then int_result = int_result + 1;

        // Convert integer value into an equivalent real value.
        real_result = Real(int_result);

        // Re-encode as a floating-point value, result is always exact.
        if real_result == 0.0 then
            result = FPZero(sign);
        else
            result = FPRound(real_result, fpcr, FPRounding\_ZERO);

        // Generate inexact exceptions.
        if error != 0.0 && exact then
            FPProcessException(FPExc\_Inexact, fpcr);

    return result;
```



```

// FPRoundIntN()
// =====

bits(N) FPRoundIntN(bits(N) op, FPCRTType fpcr, FPRounding rounding, integer intsize)
  assert rounding != FPRounding\_ODD;
  assert N IN {32,64};
  assert intsize IN {32, 64};
  integer exp;
  constant integer E = (if N == 32 then 8 else 11);
  constant integer F = N - (E + 1);

  // When alternative floating-point support is TRUE, do not generate
  // Input Denormal floating-point exceptions.
  altfp = HaveAltFP\(\) && !UsingAArch32\(\) && fpcr.AH == '1';
  fpexc = !altfp;

  // Unpack using FPCR to determine if subnormals are flushed-to-zero.
  (fptype,sign,value) = FPUnpack(op, fpcr, fpexc);

  if fptype IN {FPTType\_SNaN, FPTType\_0NaN, FPTType\_Infinity} then
    if N == 32 then
      exp = 126 + intsize;
      result = '1':exp<(E-1):0>:Zeros(F);
    else
      exp = 1022+intsize;
      result = '1':exp<(E-1):0>:Zeros(F);
      FPProcessException(FPExc\_InvalidOp, fpcr);
  elseif fptype == FPTType\_Zero then
    result = FPZero(sign);
  else
    // Extract integer component.
    int_result = RoundDown(value);
    error = value - Real(int_result);

    // Determine whether supplied rounding mode requires an increment.
    case rounding of
      when FPRounding\_TIEEVEN
        round_up = error > 0.5 || (error == 0.5 && int_result<0> == '1');
      when FPRounding\_POSINF
        round_up = error != 0.0;
      when FPRounding\_NEGINF
        round_up = FALSE;
      when FPRounding\_ZERO
        round_up = error != 0.0 && int_result < 0;
      when FPRounding\_TIEAWAY
        round_up = error > 0.5 || (error == 0.5 && int_result >= 0);

    if round_up then int_result = int_result + 1;
    overflow = int_result > 2^(intsize-1)-1 || int_result < -1*2^(intsize-1);

    if overflow then
      if N == 32 then
        exp = 126 + intsize;
        result = '1':exp<(E-1):0>:Zeros(F);
      else
        exp = 1022 + intsize;
        result = '1':exp<(E-1):0>:Zeros(F);
        FPProcessException(FPExc\_InvalidOp, fpcr);
        // This case shouldn't set Inexact.
        error = 0.0;
    else
      // Convert integer value into an equivalent real value.
      real_result = Real(int_result);

      // Re-encode as a floating-point value, result is always exact.
      if real_result == 0.0 then
        result = FPZero(sign);
      else
        result = FPRound(real_result, fpcr, FPRounding\_ZERO);

```

```
// Generate inexact exceptions.  
if error != 0.0 then  
    FPProcessException\(FPExc\_Inexact, fpcr\);  
  
return result;
```



```

// FPRsqrtEstimate()
// =====

bits(N) FPRsqrtEstimate(bits(N) operand, FPCRTType fpcr)

    assert N IN {16,32,64};

    // When using alternative floating-point behaviour, do not generate
    // floating-point exceptions and flush denormal input to zero.
    boolean altfp = HaveAltFP() && !UsingAArch32() && fpcr.AH == '1';
    boolean fpexc = !altfp;
    if altfp then fpcr.<FIZ,FZ> = '11';

    (fptype,sign,value) = FPUnpack(operand, fpcr, fpexc);

    if fptype == FPTType\_SNaN || fptype == FPTType\_0NaN then
        result = FPProcessNaN(fptype, operand, fpcr, fpexc);
    elsif fptype == FPTType\_Zero then
        result = FPInfinity(sign);
        if fpexc then FPProcessException(FPExc\_DivideByZero, fpcr);
    elsif sign == '1' then
        result = FPDefaultNaN(fpcr);
        if fpexc then FPProcessException(FPExc\_InvalidOp, fpcr);
    elsif fptype == FPTType\_Infinity then
        result = FPZero('0');
    else
        // Scale to a fixed-point value in the range 0.25 <= x < 1.0 in steps of 512, with the
        // evenness or oddness of the exponent unchanged, and calculate result exponent.
        // Scaled value has copied sign bit, exponent = 1022 or 1021 = double-precision
        // biased version of -1 or -2, fraction = original fraction extended with zeros.

        case N of
            when 16
                fraction = operand<9:0> : Zeros(42);
                exp = UInt(operand<14:10>);
            when 32
                fraction = operand<22:0> : Zeros(29);
                exp = UInt(operand<30:23>);
            when 64
                fraction = operand<51:0>;
                exp = UInt(operand<62:52>);

        if exp == 0 then
            while fraction<51> == '0' do
                fraction = fraction<50:0> : '0';
                exp = exp - 1;
            fraction = fraction<50:0> : '0';

        integer scaled;
        boolean increasedprecision = N==32 && HaveFeatRPRES() && altfp;

        if !increasedprecision then
            if exp<0> == '0' then
                scaled = UInt('1':fraction<51:44>);
            else
                scaled = UInt('01':fraction<51:45>);
        else
            if exp<0> == '0' then
                scaled = UInt('1':fraction<51:41>);
            else
                scaled = UInt('01':fraction<51:42>);

        case N of
            when 16 result_exp = ( 44 - exp) DIV 2;
            when 32 result_exp = ( 380 - exp) DIV 2;
            when 64 result_exp = (3068 - exp) DIV 2;

        estimate = RecipSqrtEstimate(scaled, increasedprecision);

        // Estimate is in the range 256 .. 511 or 4096 .. 8191 representing a

```



```

// fixed-point result in the range [1.0 .. 2.0].
// Convert to scaled floating point result with copied sign bit and high-order
// fraction bits, and exponent calculated above.
case N of
  when 16 result = '0' : result_exp<N-12:0> : estimate<7:0>:Zeros(2);
  when 32
    if !increasedprecision then
      result = '0' : result_exp<N-25:0> : estimate<7:0>:Zeros(15);
    else
      result = '0' : result_exp<N-25:0> : estimate<11:0>:Zeros(11);
  when 64 result = '0' : result_exp<N-54:0> : estimate<7:0>:Zeros(44);

return result;

```

## Library pseudocode for shared/functions/float/fprsqrtestimate/RecipSqrtEstimate

```
// RecipSqrtEstimate()
// =====
// Compute estimate of reciprocal square root of 9-bit fixed-point number.
//
// a is in range 128 .. 511 or 1024 .. 4095, with increased precision,
// representing a number in the range  $0.25 \leq x < 1.0$ .
// increasedprecision determines if the mantissa is 8-bit or 12-bit.
// result is in the range 256 .. 511 or 4096 .. 8191, with increased precision,
// representing a number in the range 1.0 to 511/256 or 8191/4096.

integer RecipSqrtEstimate(integer a, boolean increasedprecision)

    integer r;
    if !increasedprecision then
        assert 128 <= a && a < 512;
        if a < 256 then // 0.25 .. 0.5
            a = a*2+1; // a in units of 1/512 rounded to nearest
        else // 0.5 .. 1.0
            a = (a >> 1) << 1; // Discard bottom bit
            a = (a+1)*2; // a in units of 1/256 rounded to nearest
        integer b = 512;
        while a*(b+1)*(b+1) < 2^28 do
            b = b+1;
        // b = largest b such that  $b < 2^{14} / \sqrt{a}$ 
        r = (b+1) DIV 2; // Round to nearest
        assert 256 <= r && r < 512;
    else
        assert 1024 <= a && a < 4096;
        real real_val;
        real error;
        integer int_val;

        if a < 2048 then // 0.25... 0.5
            a = a*2 + 1; // Take 10 bits of fraction and force a 1 at the bottom
            real_val = Real(a)/2.0;
        else // 0.5..1.0
            a = (a >> 1) << 1; // Discard bottom bit
            a = a+1; // Taking 10 bits of the fraction and force a 1 at the bottom
            real_val = Real(a);

        real_val = Sqrt(real_val); // This number will lie in the range of 32 to 64
        // Round to nearest even for a DP float number
        real_val = real_val * Real(2^47); // The integer is the size of the whole DP mantissa
        int_val = RoundDown(real_val); // Calculate rounding value
        error = real_val - Real(int_val);
        round_up = error > 0.5; // Error cannot be exactly 0.5 so do not need tie case
        if round_up then int_val = int_val+1;

        real_val = Real(2^65)/Real(int_val); // Lies in the range  $4096 \leq \text{real\_val} < 8192$ 
        int_val = RoundDown(real_val); // Round that (to nearest even) to give integer
        error = real_val - Real(int_val);
        round_up = (error > 0.5 || (error == 0.5 && int_val<0> == '1'));
        if round_up then int_val = int_val+1;

        r = int_val;
        assert 4096 <= r && r < 8192;

    return r;
```

## Library pseudocode for shared/functions/float/fpsqrt/FPSqrt

```
// FPSqrt()
// =====

bits(N) FPSqrt(bits(N) op, FPCRTType fpcr)

    assert N IN {16,32,64};
    (fptype,sign,value) = FPUnpack(op, fpcr);

    if fptype == FPTType\_SNaN || fptype == FPTType\_0NaN then
        result = FPProcessNaN(fptype, op, fpcr);
    elsif fptype == FPTType\_Zero then
        result = FPZero(sign);
    elsif fptype == FPTType\_Infinity && sign == '0' then
        result = FPInfinity(sign);
    elsif sign == '1' then
        result = FPDefaultNaN(fpcr);
        FPProcessException(FPExc\_InvalidOp, fpcr);
    else
        result = FPRound(Sqrt(value), fpcr);

        FPProcessDenorm(fptype, N, fpcr);

    return result;
```

## Library pseudocode for shared/functions/float/fpsub/FPSub

```
// FPSub()
// =====

bits(N) FPSub(bits(N) op1, bits(N) op2, FPCRTType fpcr)

    assert N IN {16,32,64};
    rounding = FPRoundingMode(fpcr);
    (type1,sign1,value1) = FPUnpack(op1, fpcr);
    (type2,sign2,value2) = FPUnpack(op2, fpcr);
    (done,result) = FPProcessNaNs(type1, type2, op1, op2, fpcr);
    if !done then
        inf1 = (type1 == FPTType\_Infinity);
        inf2 = (type2 == FPTType\_Infinity);
        zero1 = (type1 == FPTType\_Zero);
        zero2 = (type2 == FPTType\_Zero);

        if inf1 && inf2 && sign1 == sign2 then
            result = FPDefaultNaN(fpcr);
            FPProcessException(FPExc\_InvalidOp, fpcr);
        elsif (inf1 && sign1 == '0') || (inf2 && sign2 == '1') then
            result = FPInfinity('0');
        elsif (inf1 && sign1 == '1') || (inf2 && sign2 == '0') then
            result = FPInfinity('1');
        elsif zero1 && zero2 && sign1 == NOT(sign2) then
            result = FPZero(sign1);
        else
            result_value = value1 - value2;
            if result_value == 0.0 then // Sign of exact zero result depends on rounding mode
                result_sign = if rounding == FPRounding\_NEGINF then '1' else '0';
                result = FPZero(result_sign);
            else
                result = FPRound(result_value, fpcr, rounding);

            FPProcessDenorms(type1, type2, N, fpcr);

    return result;
```

## Library pseudocode for shared/functions/float/fpthree/FPThree

```
// FPThree()
// =====

bits(N) FPThree(bit sign)

    assert N IN {16,32,64};
    constant integer E = (if N == 16 then 5 elsif N == 32 then 8 else 11);
    constant integer F = N - (E + 1);
    exp = '1':Zeros(E-1);
    frac = '1':Zeros(F-1);
    result = sign : exp : frac;

    return result;
```

## Library pseudocode for shared/functions/float/fptofixed/FPToFixed

```
// FPToFixed()
// =====

// Convert N-bit precision floating point OP to M-bit fixed point with
// FBITS fractional bits, controlled by UNSIGNED and ROUNDING.

bits(M) FPToFixed(bits(N) op, integer fbits, boolean unsigned, FPCRTYPE fpcr, FPRounding rounding)

    assert N IN {16,32,64};
    assert M IN {16,32,64};
    assert fbits >= 0;
    assert rounding != FPRounding\_ODD;

    // When alternative floating-point support is TRUE, do not generate
    // Input Denormal floating-point exceptions.
    altfp = HaveAltFP\(\) && !UsingAArch32\(\) && fpcr.AH == '1';
    fpexc = !altfp;

    // Unpack using fpcr to determine if subnormals are flushed-to-zero.
    (fptype,sign,value) = FPUnpack(op, fpcr, fpexc);

    // If NaN, set cumulative flag or take exception.
    if fptype == FPTYPE\_SNaN || fptype == FPTYPE\_QNaN then
        FPProcessException(FPExc\_InvalidOp, fpcr);

    // Scale by fractional bits and produce integer rounded towards minus-infinity.
    value = value * 2.0^fbits;
    int_result = RoundDown(value);
    error = value - Real(int_result);

    // Determine whether supplied rounding mode requires an increment.
    case rounding of
        when FPRounding\_TIEEVEN
            round_up = (error > 0.5 || (error == 0.5 && int_result<0> == '1'));
        when FPRounding\_POSINF
            round_up = (error != 0.0);
        when FPRounding\_NEGINF
            round_up = FALSE;
        when FPRounding\_ZERO
            round_up = (error != 0.0 && int_result < 0);
        when FPRounding\_TIEAWAY
            round_up = (error > 0.5 || (error == 0.5 && int_result >= 0));

    if round_up then int_result = int_result + 1;

    // Generate saturated result and exceptions.
    (result, overflow) = SatQ(int_result, M, unsigned);
    if overflow then
        FPProcessException(FPExc\_InvalidOp, fpcr);
    elsif error != 0.0 then
        FPProcessException(FPExc\_Inexact, fpcr);

    return result;
```

## Library pseudocode for shared/functions/float/fptofixedjs/FPToFixedJS

```
// FPToFixedJS()
// =====

// Converts a double precision floating point input value
// to a signed integer, with rounding to zero.

(bits(N), bit) FPToFixedJS(bits(M) op, FPCRTType fpcr, boolean Is64)

    assert M == 64 && N == 32;

    // If FALSE, never generate Input Denormal floating-point exceptions.
    fpexc_idenorm = !(HaveAltFP() && UsingAArch32() && fpcr.AH == '1');

    // Unpack using fpcr to determine if subnormals are flushed-to-zero.
    (fptype,sign,value) = FPUntpack(op, fpcr, fpexc_idenorm);

    Z = '1';
    // If NaN, set cumulative flag or take exception.
    if fptype == FPTType\_SNaN || fptype == FPTType\_QNaN then
        FPProcessException(FPExc\_InvalidOp, fpcr);
        Z = '0';

    int_result = RoundDown(value);
    error = value - Real(int_result);

    // Determine whether supplied rounding mode requires an increment.

    round_it_up = (error != 0.0 && int_result < 0);
    if round_it_up then int_result = int_result + 1;

    if int_result < 0 then
        result = int_result - 2^32*RoundUp(Real(int_result)/Real(2^32));
    else
        result = int_result - 2^32*RoundDown(Real(int_result)/Real(2^32));

    // Generate exceptions.
    if int_result < -(2^31) || int_result > (2^31)-1 then
        FPProcessException(FPExc\_InvalidOp, fpcr);
        Z = '0';
    elsif error != 0.0 then
        FPProcessException(FPExc\_Inexact, fpcr);
        Z = '0';
    elsif sign == '1' && value == 0.0 then
        Z = '0';
    elsif sign == '0' && value == 0.0 && IsZero(op<51:0>) then
        Z = '0';

    if fptype == FPTType\_Infinity then result = 0;

    return (result<N-1:0>, Z);
```

## Library pseudocode for shared/functions/float/fptwo/FPTwo

```
// FPTwo()
// =====

bits(N) FPTwo(bit sign)

    assert N IN {16,32,64};
    constant integer E = (if N == 16 then 5 elsif N == 32 then 8 else 11);
    constant integer F = N - (E + 1);
    exp = '1':Zeros(E-1);
    frac = Zeros(F);
    result = sign : exp : frac;

    return result;
```

## Library pseudocode for shared/functions/float/fptype/FPType

```
enumeration FPType {FPType_Zero,  
                    FPType_Denormal,  
                    FPType_Nonzero,  
                    FPType_Infinity,  
                    FPType_QNaN,  
                    FPType_SNaN};
```

## Library pseudocode for shared/functions/float/fpunpack/FPUnpack

```
// FPUnpack()  
// =====  
  
(FPType, bit, real) FPUnpack(bits(N) fpval, FPCRTType fpcr)  
    fpcr.AHP = '0';  
    boolean fpexc = TRUE;    // Generate floating-point exceptions  
    (fp_type, sign, value) = FPUnpackBase(fpval, fpcr, fpexc);  
    return (fp_type, sign, value);  
  
// FPUnpack()  
// =====  
//  
// Used by data processing and int/fixed <-> FP conversion instructions.  
// For half-precision data it ignores AHP, and observes FZ16.  
  
(FPType, bit, real) FPUnpack(bits(N) fpval, FPCRTType fpcr, boolean fpexc)  
    fpcr.AHP = '0';  
    (fp_type, sign, value) = FPUnpackBase(fpval, fpcr, fpexc);  
    return (fp_type, sign, value);
```





```

// FPUunpackBase()
// =====

(FPType, bit, real) FPUunpackBase(bits(N) fpval, FPCRTType fpcr)
    boolean fpexc = TRUE;    // Generate floating-point exceptions
    (fp_type, sign, value) = FPUunpackBase(fpval, fpcr, fpexc);
    return (fp_type, sign, value);

// FPUunpackBase()
// =====
//
// Unpack a floating-point number into its type, sign bit and the real number
// that it represents. The real number result has the correct sign for numbers
// and infinities, is very large in magnitude for infinities, and is 0.0 for
// NaNs. (These values are chosen to simplify the description of comparisons
// and conversions.)
//
// The 'fpcr' argument supplies FPCR control bits and 'fpexc' controls the
// generation of floating-point exceptions. Status information is updated
// directly in the FPSR where appropriate.

(FPType, bit, real) FPUunpackBase(bits(N) fpval, FPCRTType fpcr, boolean fpexc)

    assert N IN {16,32,64};

    boolean altfp = HaveAltFP() && !UsingAArch32();
    boolean fiz   = altfp && fpcr.FIZ == '1';
    boolean fz     = fpcr.FZ == '1' && !(altfp && fpcr.AH == '1');

    if N == 16 then
        sign    = fpval<15>;
        exp16   = fpval<14:10>;
        frac16  = fpval<9:0>;
        if IsZero(exp16) then
            if IsZero(frac16) || fpcr.FZ16 == '1' then
                fptype = FPType\_Zero;    value = 0.0;
            else
                fptype = FPType\_Denormal;    value = 2.0^-14 * (Real(UInt(frac16)) * 2.0^-10);
        elsif IsOnes(exp16) && fpcr.AHP == '0' then // Infinity or NaN in IEEE format
            if IsZero(frac16) then
                fptype = FPType\_Infinity;    value = 2.0^1000000;
            else
                fptype = if frac16<9> == '1' then FPType\_QNaN else FPType\_SNaN;
                value = 0.0;
        else
            fptype = FPType\_Nonzero;
            value = 2.0^(UInt(exp16)-15) * (1.0 + Real(UInt(frac16)) * 2.0^-10);

    elsif N == 32 then
        sign    = fpval<31>;
        exp32   = fpval<30:23>;
        frac32  = fpval<22:0>;

        if IsZero(exp32) then
            if IsZero(frac32) then
                // Produce zero if value is zero.
                fptype = FPType\_Zero;    value = 0.0;
            elsif fiz || fiz then // Flush-to-zero if FIZ==1 or AH,FZ==01
                fptype = FPType\_Zero;    value = 0.0;
                // Check whether to raise Input Denormal floating-point exception.
                // fpcr.FIZ==1 does not raise Input Denormal exception.
                if fz then
                    // Denormalized input flushed to zero
                    if fpexc then FPPProcessException(FPExc\_InputDenorm, fpcr);
            else
                fptype = FPType\_Denormal;    value = 2.0^-126 * (Real(UInt(frac32)) * 2.0^-23);
        elsif IsOnes(exp32) then
            if IsZero(frac32) then
                fptype = FPType\_Infinity;    value = 2.0^1000000;
            else

```

```

        fptype = if frac32<22> == '1' then FPTYPE\_QNaN else FPTYPE\_SNaN;
        value = 0.0;
    else
        fptype = FPTYPE\_Nonzero;
        value = 2.0(UInt(exp32)-127) * (1.0 + Real(UInt(frac32)) * 2.0-23);
else // N == 64
    sign = fpval<63>;
    exp64 = fpval<62:52>;
    frac64 = fpval<51:0>;

    if IsZero(exp64) then
        if IsZero(frac64) then
            // Produce zero if value is zero.
            fptype = FPTYPE\_Zero; value = 0.0;
        elsif fz || fiz then // Flush-to-zero if FIZ==1 or AH,FZ==01
            fptype = FPTYPE\_Zero; value = 0.0;
            // Check whether to raise Input Denormal floating-point exception.
            // fpcr.FIZ==1 does not raise Input Denormal exception.
            if fz then
                // Denormalized input flushed to zero
                if fpexc then FPPProcessException(FPExc\_InputDenorm, fpcr);
            else
                fptype = FPTYPE\_Denormal; value = 2.0-1022 * (Real(UInt(frac64)) * 2.0-52);
        elsif IsOnes(exp64) then
            if IsZero(frac64) then
                fptype = FPTYPE\_Infinity; value = 2.01000000;
            else
                fptype = if frac64<51> == '1' then FPTYPE\_QNaN else FPTYPE\_SNaN;
                value = 0.0;
        else
            fptype = FPTYPE\_Nonzero;
            value = 2.0(UInt(exp64)-1023) * (1.0 + Real(UInt(frac64)) * 2.0-52);

    if sign == '1' then value = -value;

    return (fptype, sign, value);

```

### Library pseudocode for shared/functions/float/fpunpack/FPUnpackCV

```

// FPUnpackCV()
// =====
//
// Used for FP <-> FP conversion instructions.
// For half-precision data ignores FZ16 and observes AHP.

(FPType, bit, real) FPUnpackCV(bits(N) fpval, FPCRTYPE fpcr)
    fpcr.FZ16 = '0';
    boolean fpexc = TRUE; // Generate floating-point exceptions
    (fp_type, sign, value) = FPUnpackBase(fpval, fpcr, fpexc);
    return (fp_type, sign, value);

```

### Library pseudocode for shared/functions/float/fpzero/FPZero

```

// FPZero()
// =====

bits(N) FPZero(bit sign)

    assert N IN {16,32,64};
    constant integer E = (if N == 16 then 5 elsif N == 32 then 8 else 11);
    constant integer F = N - (E + 1);
    exp = Zeros(E);
    frac = Zeros(F);
    result = sign : exp : frac;

    return result;

```

## Library pseudocode for shared/functions/float/vfpexpandimm/VFPExpandImm

```
// VFPExpandImm()
// =====

bits(N) VFPExpandImm(bits(8) imm8)

    assert N IN {16,32,64};
    constant integer E = (if N == 16 then 5 elsif N == 32 then 8 else 11);
    constant integer F = N - E - 1;
    sign = imm8<7>;
    exp = NOT(imm8<6>):Replicate(imm8<6>,E-3):imm8<5:4>;
    frac = imm8<3:0>:Zeros(F-4);
    result = sign : exp : frac;

    return result;
```

## Library pseudocode for shared/functions/integer/AddWithCarry

```
// AddWithCarry()
// =====
// Integer addition with carry input, returning result and NZCV flags

(bits(N), bits(4)) AddWithCarry(bits(N) x, bits(N) y, bit carry_in)
    integer unsigned_sum = UInt(x) + UInt(y) + UInt(carry_in);
    integer signed_sum = SInt(x) + SInt(y) + UInt(carry_in);
    bits(N) result = unsigned_sum<N-1:0>; // same value as signed_sum<N-1:0>
    bit n = result<N-1>;
    bit z = if IsZero(result) then '1' else '0';
    bit c = if UInt(result) == unsigned_sum then '0' else '1';
    bit v = if SInt(result) == signed_sum then '0' else '1';
    return (result, n:z:c:v);
```

## Library pseudocode for shared/functions/memory/AArch64.BranchAddr

```
// AArch64.BranchAddr()
// =====
// Return the virtual address with tag bits removed for storing to the program counter.

bits(64) AArch64.BranchAddr(bits(64) vaddress)
    assert !UsingAArch32();
    msbit = AddrTop(vaddress, TRUE, PSTATE.EL);
    if msbit == 63 then
        return vaddress;
    elsif (PSTATE.EL IN {EL0, EL1} || IsInHost()) && vaddress<msbit> == '1' then
        return SignExtend(vaddress<msbit:0>);
    else
        return ZeroExtend(vaddress<msbit:0>);
```

## Library pseudocode for shared/functions/memory/AccType

```
enumeration AccType {AccType_NORMAL, AccType_VEC,           // Normal loads and stores
                     AccType_STREAM, AccType_VECSTREAM,    // Streaming loads and stores
                     AccType_A32LSMD,                      // Load and store multiple
                     AccType_ATOMIC, AccType_ATOMICRW,     // Atomic loads and stores
                     AccType_ORDERED, AccType_ORDEREDRW,   // Load-Acquire and Store-Release
                     AccType_ORDEREDATOMIC,                // Load-Acquire and Store-Release with atomic ac
                     AccType_ORDEREDATOMICRW,
                     AccType_ATOMICLS64,                   // Atomic 64-byte loads and stores
                     AccType_LIMITEDORDERED,               // Load-LOAcquire and Store-LORelease
                     AccType_UNPRIV,                       // Load and store unprivileged
                     AccType_IFETCH,                       // Instruction fetch
                     AccType_TTW,                          // Translation table walk
                     AccType_NONFAULT,                     // Non-faulting loads
                     AccType_CNOTFIRST,                    // Contiguous FF load, not first element
                     AccType_NV2REGISTER,                  // MRS/MSR instruction used at EL1 and which is
                                                             // to a memory access that uses the EL2 translat

                     // Other operations
                     AccType_DC,                           // Data cache maintenance
                     AccType_IC,                           // Instruction cache maintenance
                     AccType_DCZVA,                        // DC ZVA instructions
                     AccType_ATPAN,                        // Address translation with PAN permission check
                     AccType_AT};                          // Address translation
```

## Library pseudocode for shared/functions/memory/AccessDescriptor

```
type AccessDescriptor is (
    AccType acctype,
    MPAMInfo mpam,
    boolean page_table_walk,
    boolean secondstage,
    boolean s2fslwalk,
    integer level
)
```

## Library pseudocode for shared/functions/memory/AddrTop

```
// AddrTop()
// =====
// Return the MSB number of a virtual address in the stage 1 translation regime for "el".
// If EL1 is using AArch64 then addresses from EL0 using AArch32 are zero-extended to 64 bits.

integer AddrTop(bits(64) address, boolean IsInstr, bits(2) el)
    assert HaveEL(el);
    regime = S1TranslationRegime(el);
    if ELUsingAArch32(regime) then
        // AArch32 translation regime.
        return 31;
    else
        if EffectiveTBI(address, IsInstr, el) == '1' then
            return 55;
        else
            return 63;
```

## Library pseudocode for shared/functions/memory/AddressDescriptor

```
type AddressDescriptor is (
    FaultRecord      fault,    // fault.statuscode indicates whether the address is valid
    MemoryAttributes memattrs,
    FullAddress      paddress,
    bits(64)         vaddress
)
```

## Library pseudocode for shared/functions/memory/Allocation

```
constant bits(2) MemHint_No = '00';    // No Read-Allocate, No Write-Allocate
constant bits(2) MemHint_WA = '01';    // No Read-Allocate, Write-Allocate
constant bits(2) MemHint_RA = '10';    // Read-Allocate, No Write-Allocate
constant bits(2) MemHint_RWA = '11';   // Read-Allocate, Write-Allocate
```

## Library pseudocode for shared/functions/memory/BigEndian

```
// BigEndian()
// =====

boolean BigEndian(AccType acctype)
    boolean bigend;
    if HaveNV2Ext\(\) && acctype == AccType\_NV2REGISTER then
        return SCTLR_EL2.EE == '1';

    if UsingAArch32\(\) then
        bigend = (PSTATE.E != '0');
    elsif PSTATE.EL == EL0 then
        bigend = (SCTLR[],EE != '0');
    else
        bigend = (SCTLR[],EE != '0');
    return bigend;
```

## Library pseudocode for shared/functions/memory/BigEndianReverse

```
// BigEndianReverse()
// =====

bits(width) BigEndianReverse (bits(width) value)
    assert width IN {8, 16, 32, 64, 128};
    integer half = width DIV 2;
    if width == 8 then return value;
    return BigEndianReverse(value<half-1:0>) : BigEndianReverse(value<width-1:half>);
```

## Library pseudocode for shared/functions/memory/Cacheability

```
constant bits(2) MemAttr_NC = '00';    // Non-cacheable
constant bits(2) MemAttr_WT = '10';    // Write-through
constant bits(2) MemAttr_WB = '11';    // Write-back
```

## Library pseudocode for shared/functions/memory/CreateAccessDescriptor

```
// CreateAccessDescriptor()
// =====

AccessDescriptor CreateAccessDescriptor(AccType acctype)
    AccessDescriptor accdesc;
    accdesc.acctype = acctype;
    accdesc.mpam = GenMPAMcurEL(acctype);
    accdesc.page_table_walk = FALSE;
    return accdesc;
```

## Library pseudocode for shared/functions/memory/CreateAccessDescriptorTTW

```
// CreateAccessDescriptorTTW()
// =====

AccessDescriptor CreateAccessDescriptorTTW(AccType acctype, boolean secondstage,
                                           boolean s2fslwalk, integer level)

    AccessDescriptor accdesc;
    accdesc.acctype = acctype;
    accdesc.mpam = GenMPAMcurEL(acctype);
    accdesc.page_table_walk = TRUE;
    accdesc.s2fslwalk = s2fslwalk;
    accdesc.secondstage = secondstage;
    accdesc.level = level;
    return accdesc;
```

## Library pseudocode for shared/functions/memory/DataMemoryBarrier

```
DataMemoryBarrier(MBReqDomain domain, MBReqTypes types);
```

## Library pseudocode for shared/functions/memory/DataSynchronizationBarrier

```
DataSynchronizationBarrier(MBReqDomain domain, MBReqTypes types, boolean nXS);
```

## Library pseudocode for shared/functions/memory/DeviceType

```
enumeration DeviceType {DeviceType_GRE, DeviceType_nGRE, DeviceType_nGnRE, DeviceType_nGnRnE};
```

## Library pseudocode for shared/functions/memory/EffectiveTBI

```
// EffectiveTBI()
// =====
// Returns the effective TBI in the AArch64 stage 1 translation regime for "el".

bit EffectiveTBI(bits(64) address, boolean IsInstr, bits(2) el)
    assert HaveEL(el);
    regime = S1TranslationRegime(el);
    assert(!ELUsingAArch32(regime));

    case regime of
        when EL1
            tbi = if address<55> == '1' then TCR_EL1.TBI1 else TCR_EL1.TBI0;
            if HavePACEExt() then
                tbid = if address<55> == '1' then TCR_EL1.TBID1 else TCR_EL1.TBID0;
        when EL2
            if HaveVirtHostExt() && ELIsInHost(el) then
                tbi = if address<55> == '1' then TCR_EL2.TBI1 else TCR_EL2.TBI0;
                if HavePACEExt() then
                    tbid = if address<55> == '1' then TCR_EL2.TBID1 else TCR_EL2.TBID0;
            else
                tbi = TCR_EL2.TBI;
                if HavePACEExt() then tbid = TCR_EL2.TBID;
        when EL3
            tbi = TCR_EL3.TBI;
            if HavePACEExt() then tbid = TCR_EL3.TBID;

    return (if tbi == '1' && (!HavePACEExt() || tbid == '0' || !IsInstr) then '1' else '0');
```

## Library pseudocode for shared/functions/memory/EffectiveTCMA

```
// EffectiveTCMA()
// =====
// Returns the effective TCMA of a virtual address in the stage 1 translation regime for "el".

bit EffectiveTCMA(bits(64) address, bits(2) el)
    assert HaveEL(el);
    regime = S1TranslationRegime(el);
    assert(!ELUsingAArch32(regime));

    case regime of
        when EL1
            tcma = if address<55> == '1' then TCR_EL1.TCMA1 else TCR_EL1.TCMA0;
        when EL2
            if HaveVirtHostExt() && ELIsInHost(el) then
                tcma = if address<55> == '1' then TCR_EL2.TCMA1 else TCR_EL2.TCMA0;
            else
                tcma = TCR_EL2.TCMA;
        when EL3
            tcma = TCR_EL3.TCMA;

    return tcma;
```

## Library pseudocode for shared/functions/memory/Fault

```
enumeration Fault {Fault_None,
    Fault_AccessFlag,
    Fault_Alignment,
    Fault_Background,
    Fault_Domain,
    Fault_Permission,
    Fault_Translation,
    Fault_AddressSize,
    Fault_SyncExternal,
    Fault_SyncExternalOnWalk,
    Fault_SyncParity,
    Fault_SyncParityOnWalk,
    Fault_AsyncParity,
    Fault_AsyncExternal,
    Fault_Debug,
    Fault_TLBConflict,
    Fault_BranchTarget,
    Fault_HWUpdateAccessFlag,
    Fault_Lockdown,
    Fault_Exclusive,
    Fault_ICacheMaint};
```

## Library pseudocode for shared/functions/memory/FaultRecord

```
type FaultRecord is (Fault    statuscode, // Fault Status
    AccType acctype,         // Type of access that faulted
    FullAddress ipaddress,    // Intermediate physical address
    boolean s2fslwalk,       // Is on a Stage 1 translation table walk
    boolean write,           // TRUE for a write, FALSE for a read
    integer level,           // For translation, access flag and permission faults
    bit extflag,             // IMPLEMENTATION DEFINED syndrome for External aborts
    boolean secondstage,     // Is a Stage 2 abort
    bits(4) domain,          // Domain number, AArch32 only
    bits(2) errortype,        // [Armv8.2 RAS] AArch32 AET or AArch64 SET
    bits(4) debugmoe)        // Debug method of entry, from AArch32 only
```

## Library pseudocode for shared/functions/memory/FullAddress

```
type FullAddress is (
    PASpace paspace,
    bits(52) address
)
```

## Library pseudocode for shared/functions/memory/Hint\_Prefetch

```
// Signals the memory system that memory accesses of type HINT to or from the specified address are
// likely in the near future. The memory system may take some action to speed up the memory
// accesses when they do occur, such as pre-loading the the specified address into one or more
// caches as indicated by the innermost cache level target (0=L1, 1=L2, etc) and non-temporal hint
// stream. Any or all prefetch hints may be treated as a NOP. A prefetch hint must not cause a
// synchronous abort due to Alignment or Translation faults and the like. Its only effect on
// software-visible state should be on caches and TLBs associated with address, which must be
// accessible by reads, writes or execution, as defined in the translation regime of the current
// Exception level. It is guaranteed not to access Device memory.
// A Prefetch_EXEC hint must not result in an access that could not be performed by a speculative
// instruction fetch, therefore if all associated MMUs are disabled, then it cannot access any
// memory location that cannot be accessed by instruction fetches.
Hint_Prefetch(bits(64) address, PrefetchHint hint, integer target, boolean stream);
```

## Library pseudocode for shared/functions/memory/MBReqDomain

```
enumeration MBReqDomain    {MBReqDomain_Nonshareable, MBReqDomain_InnerShareable,
                             MBReqDomain_OuterShareable, MBReqDomain_FullSystem};
```

## Library pseudocode for shared/functions/memory/MBReqTypes

```
enumeration MBReqTypes     {MBReqTypes_Reads, MBReqTypes_Writes, MBReqTypes_All};
```

## Library pseudocode for shared/functions/memory/MPAM

```
type PARTIDtype = bits(16);
type PMGtype = bits(8);
type PARTIDspaceType = bit;
constant PARTIDspaceType PIdSpace_Secure    = '0';
constant PARTIDspaceType PIdSpace_NonSecure = '1';

type MPAMinfo is (
    PARTIDspaceType mpam_ns,
    PARTIDtype partid,
    PMGtype pmg
)
```

## Library pseudocode for shared/functions/memory/MemAttrHints

```
type MemAttrHints is (
    bits(2) attrs, // See MemAttr_*, Cacheability attributes
    bits(2) hints, // See MemHint_*, Allocation hints
    boolean transient
)
```

## Library pseudocode for shared/functions/memory/MemType

```
enumeration MemType {MemType_Normal, MemType_Device};
```

## Library pseudocode for shared/functions/memory/MemoryAttributes

```
type MemoryAttributes is (
    MemType memtype,
    DeviceType device, // For Device memory types
    MemAttrHints inner, // Inner hints and attributes
    MemAttrHints outer, // Outer hints and attributes
    Shareability shareability, // Shareability attribute
    boolean tagged, // Tagged access
    bit xs // XS attribute
)
```



## Library pseudocode for shared/functions/memory/PASpace

```
enumeration PASpace {
    PAS_NonSecure,
    PAS_Secure,
};
```

## Library pseudocode for shared/functions/memory/Permissions

```
type Permissions is (
    bits(2) ap_table,    // Stage 1 hierarchical access permissions
    bit     xn_table,    // Stage 1 hierarchical execute-never for single EL regimes
    bit     pxn_table,   // Stage 1 hierarchical privileged execute-never
    bit     uxn_table,   // Stage 1 hierarchical unprivileged execute-never
    bits(3) ap,          // Stage 1 access permissions
    bit     xn,          // Stage 1 execute-never for single EL regimes
    bit     uxn,         // Stage 1 unprivileged execute-never
    bit     pxn,         // Stage 1 privileged execute-never
    bits(2) s2ap,        // Stage 2 access permissions
    bit     s2xnx,       // Stage 2 extended execute-never
    bit     s2xn         // Stage 2 execute-never
)
```

## Library pseudocode for shared/functions/memory/PrefetchHint

```
enumeration PrefetchHint {Prefetch_READ, Prefetch_WRITE, Prefetch_EXEC};
```

## Library pseudocode for shared/functions/memory/Shareability

```
enumeration Shareability {
    Shareability_NSH,
    Shareability_ISH,
    Shareability_OSH
};
```

## Library pseudocode for shared/functions/memory/SpeculativeStoreBypassBarrierToPA

```
SpeculativeStoreBypassBarrierToPA();
```

## Library pseudocode for shared/functions/memory/SpeculativeStoreBypassBarrierToVA

```
SpeculativeStoreBypassBarrierToVA();
```

## Library pseudocode for shared/functions/memory/Tag

```
constant integer LOG2_TAG_GRANULE = 4;
constant integer TAG_GRANULE = 1 << LOG2_TAG_GRANULE;
```

## Library pseudocode for shared/functions/memory/\_Mem

```
// These two _Mem[] accessors are the hardware operations which perform single-copy atomic,
// aligned, little-endian memory accesses of size bytes from/to the underlying physical
// memory array of bytes.
//
// The functions address the array using desc.paddress which supplies:
// * A 52-bit physical address
// * A single NS bit to select between Secure and Non-secure parts of the array.
//
// The accdesc descriptor describes the access type: normal, exclusive, ordered, streaming,
// etc and other parameters required to access the physical memory or for setting syndrome
// register in the event of an External abort.
bits(8*size) _Mem[AddressDescriptor desc, integer size, AccessDescriptor accdesc];

_Mem[AddressDescriptor desc, integer size, AccessDescriptor accdesc] = bits(8*size) value;
```

## Library pseudocode for shared/functions/mpam/DefaultMPAMInfo

```
// DefaultMPAMInfo()
// =====
// Returns default MPAM info. The partidspace argument sets
// the PARTID space of the default MPAM information returned.

MPAMInfo DefaultMPAMInfo(PARTIDspaceType partidspace)
    MPAMInfo DefaultInfo;
    DefaultInfo.mpam_ns = partidspace;
    DefaultInfo.partid = DefaultPARTID;
    DefaultInfo.pmg = DefaultPMG;
    return DefaultInfo;
```

## Library pseudocode for shared/functions/mpam/DefaultPARTID

```
constant PARTIDtype DefaultPARTID = 0<15:0>;
```

## Library pseudocode for shared/functions/mpam/DefaultPMG

```
constant PMGtype DefaultPMG = 0<7:0>;
```

## Library pseudocode for shared/functions/mpam/GenMPAMcurEL

```
// GenMPAMcurEL
// =====
// Returns MPAMInfo for the current EL and security state.
// May be called if MPAM is not implemented (but in a version that supports
// MPAM), MPAM is disabled, or in AArch32. In AArch32, convert the mode to
// EL if can and use that to drive MPAM information generation. If mode
// cannot be converted, MPAM is not implemented, or MPAM is disabled return
// default MPAM information for the current security state.

MPAMInfo GenMPAMcurEL(AccType acctype)
    bits(2) mpamEL;
    boolean validEL = FALSE;
    SecurityState security = if IsSecure() then SS_Secure else SS_NonSecure;
    boolean InD = FALSE;
    PARTIDspaceType pspace;
    if UsingAArch32() then
        (validEL, mpamEL) = ELFromM32(PSTATE.M);
    else
        mpamEL = PSTATE.EL;
        validEL = TRUE;
    case acctype of
        when AccType_IFETCH, AccType_IC
            InD = TRUE;
        otherwise
            // other access types are DATA accesses
            InD = FALSE;
    pspace = PARTIDspaceFromSS(security);
    if !validEL then
        return DefaultMPAMInfo(pspace);
    if HaveEMPAMExt() && pspace == PIdSpace_Secure then
        if MPAM3_EL3.FORCE_NS == '1' then
            pspace = PIdSpace_NonSecure;
        if MPAM3_EL3.SDEFLT == '1' then
            return DefaultMPAMInfo(pspace);
    return genMPAM(mpamEL, InD, pspace);
```

## Library pseudocode for shared/functions/mpam/MAP\_vPARTID

```
// MAP_vPARTID
// =====
// Performs conversion of virtual PARTID into physical PARTID
// Contains all of the error checking and implementation
// choices for the conversion.

(PARTIDtype, boolean) MAP_vPARTID(PARTIDtype vpartid)
    // should not ever be called if EL2 is not implemented
    // or is implemented but not enabled in the current
    // security state.
    PARTIDtype ret;
    boolean err;
    integer virt    = UInt(vpartid);
    integer vpmrmax = UInt(MPAMIDR_EL1.VPMR_MAX);

    // vpartid_max is largest vpartid supported
    integer vpartid_max = (vpmrmax << 2) + 3;

    // One of many ways to reduce vpartid to value less than vpartid_max.
    if UInt(vpartid) > vpartid_max then
        virt = virt MOD (vpartid_max+1);

    // Check for valid mapping entry.
    if MPAMVPMV_EL2<virt> == '1' then
        // vpartid has a valid mapping so access the map.
        ret = mapvpmw(virt);
        err = FALSE;

    // Is the default virtual PARTID valid?
    elsif MPAMVPMV_EL2<0> == '1' then
        // Yes, so use default mapping for vpartid == 0.
        ret = MPAMVPM0_EL2<0 +: 16>;
        err = FALSE;

    // Neither is valid so use default physical PARTID.
    else
        ret = DefaultPARTID;
        err = TRUE;

    // Check that the physical PARTID is in-range.
    // This physical PARTID came from a virtual mapping entry.
    integer partid_max = UInt(MPAMIDR_EL1.PARTID_MAX);
    if UInt(ret) > partid_max then
        // Out of range, so return default physical PARTID
        ret = DefaultPARTID;
        err = TRUE;
    return (ret, err);
```

## Library pseudocode for shared/functions/mpam/MPAMisEnabled

```
// MPAMisEnabled
// =====
// Returns TRUE if MPAMisEnabled.

boolean MPAMisEnabled()
    el = HighestEL();
    case el of
        when EL3 return MPAM3_EL3.MPAMEN == '1';
        when EL2 return MPAM2_EL2.MPAMEN == '1';
        when EL1 return MPAM1_EL1.MPAMEN == '1';
```

## Library pseudocode for shared/functions/mpam/MPAMisVirtual

```
// MPAMisVirtual
// =====
// Returns TRUE if MPAM is configured to be virtual at EL.

boolean MPAMisVirtual(bits(2) el)
    return (MPAMIDR_EL1.HAS_HCR == '1' && EL2Enabled\(\) &&
            ((el == EL0 && MPAMHCR_EL2.EL0_VPMEN == '1' &&
              (HCR_EL2.E2H == '0' || HCR_EL2.TGE == '0')) ||
             (el == EL1 && MPAMHCR_EL2.EL1_VPMEN == '1')));
```

## Library pseudocode for shared/functions/mpam/PARTIDspaceFromSS

```
// PARTIDspaceFromSS
// =====
// Returns the primary PARTID space from the Security State.

PARTIDspaceType PARTIDspaceFromSS(SecurityState security)
    case security of
        when SS\_NonSecure
            return PIdSpace\_NonSecure;
        when SS\_Secure
            if HaveEMPAMExt\(\) && MPAM3_EL3.FORCE_NS == '1' then
                return PIdSpace\_NonSecure;
            else
                return PIdSpace\_Secure;
        otherwise
            Unreachable\(\);
```

## Library pseudocode for shared/functions/mpam/genMPAM

```
// genMPAM
// =====
// Returns MPAMinfo for exception level el.
// If InD is TRUE returns MPAM information using PARTID_I and PMG_I fields
// of MPAMel_ELx register and otherwise using PARTID_D and PMG_D fields.
// Produces a PARTID in PARTID space pspace.

MPAMinfo genMPAM(bits(2) el, boolean InD, PARTIDspaceType pspace)
    MPAMinfo returninfo;
    PARTIDtype partidel;
    boolean perr;
    // gstplk is guest OS application locked by the EL2 hypervisor to
    // only use EL1 the virtual machine's PARTIDs.
    boolean gstplk = (el == EL0 && EL2Enabled\(\) &&
                     MPAMHCR_EL2.GSTAPP_PLK == '1' &&
                     HCR_EL2.TGE == '0');
    bits(2) eff_el = if gstplk then EL1 else el;
    (partidel, perr) = genPARTID(eff_el, InD);
    PMGtype groupel = genPMG(eff_el, InD, perr);
    returninfo.mpam_ns = pspace;
    returninfo.partid = partidel;
    returninfo.pmg = groupel;
    return returninfo;
```

## Library pseudocode for shared/functions/mpam/genMPAMel

```
// genMPAMel
// =====
// Returns MPAMinfo for specified EL in the current security state.
// InD is TRUE for instruction access and FALSE otherwise.

MPAMinfo genMPAMel(bits(2) el, boolean InD)
    SecurityState security = SecurityStateAtEL(el);
    PARTIDspaceType space = PARTIDspaceFromSS(security);
    boolean use_default = !(HaveMPAMExt() && MPAMisEnabled());
    if HaveEMPAMExt() && space == PIdSpace_Secure then
        if MPAM3_EL3.FORCE_NS == '1' then
            space = PIdSpace_NonSecure;
        if MPAM3_EL3.SDEFLT == '1' then
            use_default = TRUE;
    if !use_default then
        return genMPAM(el, InD, space);
    else
        return DefaultMPAMinfo(space);
```

## Library pseudocode for shared/functions/mpam/genPARTID

```
// genPARTID
// =====
// Returns physical PARTID and error boolean for exception level el.
// If InD is TRUE then PARTID is from MPAMel_ELx.PARTID_I and
// otherwise from MPAMel_ELx.PARTID_D.

(PARTIDtype, boolean) genPARTID(bits(2) el, boolean InD)
    PARTIDtype partidel = getMPAM_PARTID(el, InD);
    PARTIDtype partid_max = MPAMIDR_EL1.PARTID_MAX;
    if UInt(partidel) > UInt(partid_max) then
        return (DefaultPARTID, TRUE);
    if MPAMisVirtual(el) then
        return MAP_vPARTID(partidel);
    else
        return (partidel, FALSE);
```

## Library pseudocode for shared/functions/mpam/genPMG

```
// genPMG
// =====
// Returns PMG for exception level el and I- or D-side (InD).
// If PARTID generation (genPARTID) encountered an error, genPMG() should be
// called with partid_err as TRUE.

PMGtype genPMG(bits(2) el, boolean InD, boolean partid_err)
    integer pmg_max = UInt(MPAMIDR_EL1.PMG_MAX);
    // It is CONSTRAINED UNPREDICTABLE whether partid_err forces PMG to
    // use the default or if it uses the PMG from getMPAM_PMG.
    if partid_err then
        return DefaultPMG;
    PMGtype groupel = getMPAM_PMG(el, InD);
    if UInt(groupel) <= pmg_max then
        return groupel;
    return DefaultPMG;
```

## Library pseudocode for shared/functions/mpam/getMPAM\_PARTID

```
// getMPAM_PARTID
// =====
// Returns a PARTID from one of the MPAMn_ELx registers.
// MPAMn selects the MPAMn_ELx register used.
// If InD is TRUE, selects the PARTID_I field of that
// register. Otherwise, selects the PARTID_D field.

PARTIDtype getMPAM_PARTID(bits(2) MPAMn, boolean InD)
    PARTIDtype partid;
    boolean el2avail = EL2Enabled();

    if InD then
        case MPAMn of
            when '11' partid = MPAM3_EL3.PARTID_I;
            when '10' partid = if el2avail then MPAM2_EL2.PARTID_I else Zeros();
            when '01' partid = MPAM1_EL1.PARTID_I;
            when '00' partid = MPAM0_EL1.PARTID_I;
            otherwise partid = PARTIDtype UNKNOWN;
    else
        case MPAMn of
            when '11' partid = MPAM3_EL3.PARTID_D;
            when '10' partid = if el2avail then MPAM2_EL2.PARTID_D else Zeros();
            when '01' partid = MPAM1_EL1.PARTID_D;
            when '00' partid = MPAM0_EL1.PARTID_D;
            otherwise partid = PARTIDtype UNKNOWN;
    return partid;
```

## Library pseudocode for shared/functions/mpam/getMPAM\_PMG

```
// getMPAM_PMG
// =====
// Returns a PMG from one of the MPAMn_ELx registers.
// MPAMn selects the MPAMn_ELx register used.
// If InD is TRUE, selects the PMG_I field of that
// register. Otherwise, selects the PMG_D field.

PMGtype getMPAM_PMG(bits(2) MPAMn, boolean InD)
    PMGtype pmg;
    boolean el2avail = EL2Enabled();

    if InD then
        case MPAMn of
            when '11' pmg = MPAM3_EL3.PMG_I;
            when '10' pmg = if el2avail then MPAM2_EL2.PMG_I else Zeros();
            when '01' pmg = MPAM1_EL1.PMG_I;
            when '00' pmg = MPAM0_EL1.PMG_I;
            otherwise pmg = PMGtype UNKNOWN;
    else
        case MPAMn of
            when '11' pmg = MPAM3_EL3.PMG_D;
            when '10' pmg = if el2avail then MPAM2_EL2.PMG_D else Zeros();
            when '01' pmg = MPAM1_EL1.PMG_D;
            when '00' pmg = MPAM0_EL1.PMG_D;
            otherwise pmg = PMGtype UNKNOWN;
    return pmg;
```

## Library pseudocode for shared/functions/mpam/mapvpmw

```
// mapvpmw
// =====
// Map a virtual PARTID into a physical PARTID using
// the MPAMVPMn_EL2 registers.
// vpartid is now assumed in-range and valid (checked by caller)
// returns physical PARTID from mapping entry.

PARTIDtype mapvpmw(integer vpartid)
    bits(64) vpmw;
    integer wd = vpartid DIV 4;
    case wd of
        when 0 vpmw = MPAMVPM0_EL2;
        when 1 vpmw = MPAMVPM1_EL2;
        when 2 vpmw = MPAMVPM2_EL2;
        when 3 vpmw = MPAMVPM3_EL2;
        when 4 vpmw = MPAMVPM4_EL2;
        when 5 vpmw = MPAMVPM5_EL2;
        when 6 vpmw = MPAMVPM6_EL2;
        when 7 vpmw = MPAMVPM7_EL2;
        otherwise vpmw = Zeros(64);
    // vpme_lsb selects LSB of field within register
    integer vpme_lsb = (vpartid MOD 4) * 16;
    return vpmw<vpme_lsb+: 16>;
```

## Library pseudocode for shared/functions/registers/BranchTo

```
// BranchTo()
// =====
// Set program counter to a new address, with a branch type.
// Parameter branch_conditional indicates whether the executed branch has a conditional encoding.
// In AArch64 state the address might include a tag in the top eight bits.

BranchTo(bits(N) target, BranchType branch_type, boolean branch_conditional)
    Hint_Branch(branch_type);
    if N == 32 then
        assert UsingAArch32();
        _PC = ZeroExtend(target);
    else
        assert N == 64 && !UsingAArch32();
        bits(64) target_vaddress = AArch64.BranchAddr(target<63:0>);
        _PC = target_vaddress;
    return;
```

## Library pseudocode for shared/functions/registers/BranchToAddr

```
// BranchToAddr()
// =====
// Set program counter to a new address, with a branch type.
// In AArch64 state the address does not include a tag in the top eight bits.

BranchToAddr(bits(N) target, BranchType branch_type)
    Hint_Branch(branch_type);
    if N == 32 then
        assert UsingAArch32();
        _PC = ZeroExtend(target);
    else
        assert N == 64 && !UsingAArch32();
        _PC = target<63:0>;
    return;
```

## Library pseudocode for shared/functions/registers/BranchType

```
enumeration BranchType {
    BranchType_DIRCALL,    // Direct Branch with link
    BranchType_INDCALL,    // Indirect Branch with link
    BranchType_ERET,       // Exception return (indirect)
    BranchType_DBGEXIT,    // Exit from Debug state
    BranchType_RET,        // Indirect branch with function return hint
    BranchType_DIR,        // Direct branch
    BranchType_INDIR,      // Indirect branch
    BranchType_EXCEPTION,  // Exception entry
    BranchType_RESET,      // Reset
    BranchType_UNKNOWN};   // Other
```

## Library pseudocode for shared/functions/registers/Hint\_Branch

```
// Report the hint passed to BranchTo() and BranchToAddr(), for consideration when processing
// the next instruction.
Hint_Branch(BranchType hint);
```

## Library pseudocode for shared/functions/registers/NextInstrAddr

```
// Return address of the sequentially next instruction.
bits(N) NextInstrAddr();
```

## Library pseudocode for shared/functions/registers/ResetExternalDebugRegisters

```
// Reset the External Debug registers in the Core power domain.
ResetExternalDebugRegisters(boolean cold_reset);
```

## Library pseudocode for shared/functions/registers/ThisInstrAddr

```
// ThisInstrAddr()
// =====
// Return address of the current instruction.

bits(N) ThisInstrAddr()
    assert N == 64 || (N == 32 && UsingAArch32\(\));
    return _PC<N-1:0>;
```

## Library pseudocode for shared/functions/registers/\_PC

```
bits(64) _PC;
```

## Library pseudocode for shared/functions/registers/\_R

```
array bits(64) _R[0..30];
```



## Library pseudocode for shared/functions/sysregisters/SPSR

```
// SPSR[] - non-assignment form
// =====

bits(N) SPSR[]
  bits(N) result;
  if UsingAArch32() then
    assert N == 32;
    case PSTATE.M of
      when M32_FIQ      result = SPSR_fiq<N-1:0>;
      when M32_IRQ      result = SPSR_irq<N-1:0>;
      when M32_Svc       result = SPSR_svc<N-1:0>;
      when M32_Monitor   result = SPSR_mon<N-1:0>;
      when M32_Abort     result = SPSR_abt<N-1:0>;
      when M32_Hyp       result = SPSR_hyp<N-1:0>;
      when M32_Undef     result = SPSR_und<N-1:0>;
      otherwise          Unreachable();
  else
    assert N == 64;
    case PSTATE.EL of
      when EL1           result = SPSR_EL1<N-1:0>;
      when EL2           result = SPSR_EL2<N-1:0>;
      when EL3           result = SPSR_EL3<N-1:0>;
      otherwise          Unreachable();
  return result;

// SPSR[] - assignment form
// =====

SPSR[] = bits(N) value
  if UsingAArch32() then
    assert N == 32;
    case PSTATE.M of
      when M32_FIQ      SPSR_fiq = ZeroExtend(value);
      when M32_IRQ      SPSR_irq = ZeroExtend(value);
      when M32_Svc       SPSR_svc = ZeroExtend(value);
      when M32_Monitor   SPSR_mon = ZeroExtend(value);
      when M32_Abort     SPSR_abt = ZeroExtend(value);
      when M32_Hyp       SPSR_hyp = ZeroExtend(value);
      when M32_Undef     SPSR_und = ZeroExtend(value);
      otherwise          Unreachable();
  else
    assert N == 64;
    case PSTATE.EL of
      when EL1           SPSR_EL1 = ZeroExtend(value);
      when EL2           SPSR_EL2 = ZeroExtend(value);
      when EL3           SPSR_EL3 = ZeroExtend(value);
      otherwise          Unreachable();
  return;
```

## Library pseudocode for shared/functions/system/ArchVersion

```
enumeration ArchVersion {
  ARMv8p0
  , ARMv8p1
  , ARMv8p2
  , ARMv8p3
  , ARMv8p4
  , ARMv8p5
  , ARMv8p6
  , ARMv8p7
};
```

## Library pseudocode for shared/functions/system/BranchTargetCheck

```
// BranchTargetCheck()
// =====
// This function is executed checks if the current instruction is a valid target for a branch
// taken into, or inside, a guarded page. It is executed on every cycle once the current
// instruction has been decoded and the values of InGuardedPage and BTypeCompatible have been
// determined for the current instruction.

BranchTargetCheck()
    assert HaveBTIExt() && !UsingAArch32();

    // The branch target check considers two state variables:
    // * InGuardedPage, which is evaluated during instruction fetch.
    // * BTypeCompatible, which is evaluated during instruction decode.
    if InGuardedPage && PSTATE.BTYPE != '00' && !BTypeCompatible && !Halted() then
        bits(64) pc = ThisInstrAddr();
        AArch64.BranchTargetException(pc<51:0>);

    boolean branch_instr = AArch64.ExecutingBR0rBLR0rRetInstr();
    boolean bti_instr    = AArch64.ExecutingBTIIInstr();

    // PSTATE.BTYPE defaults to 00 for instructions that do not explicitly set BTYPE.
    if !(branch_instr || bti_instr) then
        BTypeNext = '00';
```

## Library pseudocode for shared/functions/system/ClearEventRegister

```
// ClearEventRegister()
// =====
// Clear the Event Register of this PE.

ClearEventRegister()
    EventRegister = '0';
    return;
```

## Library pseudocode for shared/functions/system/ClearPendingPhysicalSError

```
// Clear a pending physical SError interrupt.
ClearPendingPhysicalSError();
```

## Library pseudocode for shared/functions/system/ClearPendingVirtualSError

```
// Clear a pending virtual SError interrupt.
ClearPendingVirtualSError();
```

## Library pseudocode for shared/functions/system/ConditionHolds

```
// ConditionHolds()
// =====
// Return TRUE iff COND currently holds

boolean ConditionHolds(bits(4) cond)
// Evaluate base condition.
case cond<3:1> of
  when '000' result = (PSTATE.Z == '1');           // EQ or NE
  when '001' result = (PSTATE.C == '1');           // CS or CC
  when '010' result = (PSTATE.N == '1');           // MI or PL
  when '011' result = (PSTATE.V == '1');           // VS or VC
  when '100' result = (PSTATE.C == '1' && PSTATE.Z == '0'); // HI or LS
  when '101' result = (PSTATE.N == PSTATE.V);       // GE or LT
  when '110' result = (PSTATE.N == PSTATE.V && PSTATE.Z == '0'); // GT or LE
  when '111' result = TRUE;                         // AL

// Condition flag values in the set '111x' indicate always true
// Otherwise, invert condition if necessary.
if cond<0> == '1' && cond != '1111' then
  result = !result;

return result;
```

## Library pseudocode for shared/functions/system/ConsumptionOfSpeculativeDataBarrier

```
ConsumptionOfSpeculativeDataBarrier();
```

## Library pseudocode for shared/functions/system/CurrentInstrSet

```
// CurrentInstrSet()
// =====

InstrSet CurrentInstrSet()

if UsingAArch32\(\) then
  result = if PSTATE.T == '0' then InstrSet\_A32 else InstrSet\_T32;
  // PSTATE.J is RES0. Implementation of T32EE or Jazelle state not permitted.
else
  result = InstrSet\_A64;
return result;
```

## Library pseudocode for shared/functions/system/CurrentPL

```
// CurrentPL()
// =====

PrivilegeLevel CurrentPL()
  return PLOfEL(PSTATE.EL);
```

## Library pseudocode for shared/functions/system/EL0

```
constant bits(2) EL3 = '11';
constant bits(2) EL2 = '10';
constant bits(2) EL1 = '01';
constant bits(2) EL0 = '00';
```

## Library pseudocode for shared/functions/system/EL2Enabled

```
// EL2Enabled()
// =====
// Returns TRUE if EL2 is present and executing
// - with SCR_EL3.NS==1 when Non-secure EL2 is implemented, or
// - with SCR_EL3.NS==0 when Secure EL2 is implemented and enabled, or
// - when EL3 is not implemented.

boolean EL2Enabled()
    return HaveEL(EL2) && (!HaveEL(EL3) || SCR_EL3.NS == '1' || IsSecureEL2Enabled());
```

## Library pseudocode for shared/functions/system/ELFromM32

```
// ELFromM32()
// =====

(boolean, bits(2)) ELFromM32(bits(5) mode)
    // Convert an AArch32 mode encoding to an Exception level.
    // Returns (valid, EL):
    //   'valid' is TRUE if 'mode<4:0>' encodes a mode that is both valid for this implementation
    //           and the current value of SCR.NS/SCR_EL3.NS.
    //   'EL'    is the Exception level decoded from 'mode'.
    bits(2) el;
    boolean valid = !BadMode(mode); // Check for modes that are not valid for this implementation
    case mode of
        when M32_Monitor
            el = EL3;
        when M32_Hyp
            el = EL2;
            valid = valid && (!HaveEL(EL3) || SCR_GEN[].NS == '1');
        when M32_FIQ, M32_IRQ, M32_Svc, M32_Abort, M32_Undef, M32_System
            // If EL3 is implemented and using AArch32, then these modes are EL3 modes in Secure
            // state, and EL1 modes in Non-secure state. If EL3 is not implemented or is using
            // AArch64, then these modes are EL1 modes.
            el = (if HaveEL(EL3) && HighestELUsingAArch32() && SCR.NS == '0' then EL3 else EL1);
        when M32_User
            el = EL0;
        otherwise
            valid = FALSE; // Passed an illegal mode value
    if !valid then el = bits(2) UNKNOWN;
    return (valid, el);
```

## Library pseudocode for shared/functions/system/ELFromSPSR

```
// ELFromSPSR()
// =====

// Convert an SPSR value encoding to an Exception level.
// Returns (valid,EL):
//   'valid' is TRUE if 'spsr<4:0>' encodes a valid mode for the current state.
//   'EL'    is the Exception level decoded from 'spsr'.

(boolean, bits(2)) ELFromSPSR(bits(N) spsr)
    if spsr<4> == '0' then // AArch64 state
        el = spsr<3:2>;
        if HighestELUsingAArch32\(\) then // No AArch64 support
            valid = FALSE;
        elseif !HaveEL(el) then // Exception level not implemented
            valid = FALSE;
        elseif spsr<1> == '1' then // M[1] must be 0
            valid = FALSE;
        elseif el == EL0 && spsr<0> == '1' then // for EL0, M[0] must be 0
            valid = FALSE;
        elseif el == EL2 && HaveEL(EL3) && !IsSecureEL2Enabled() && SCR_EL3.NS == '0' then
            valid = FALSE; // Unless Secure EL2 is enabled, EL2 only valid in Non-secure state
        else
            valid = TRUE;
    elseif HaveAnyAArch32() then // AArch32 state
        (valid, el) = ELFromM32(spsr<4:0>);
    else
        valid = FALSE;

    if !valid then el = bits(2) UNKNOWN;
    return (valid, el);
```

## Library pseudocode for shared/functions/system/ELIsInHost

```
// ELIsInHost()
// =====

boolean ELIsInHost(bits(2) el)
    if !HaveVirtHostExt() || ELUsingAArch32(EL2) then
        return FALSE;
    case el of
        when EL3
            return FALSE;
        when EL2
            return HCR_EL2.E2H == '1';
        when EL1
            return FALSE;
        when EL0
            return EL2Enabled() && HCR_EL2.<E2H,TGE> == '11';
        otherwise
            Unreachable();
```

## Library pseudocode for shared/functions/system/ELStateUsingAArch32

```
// ELStateUsingAArch32()
// =====

boolean ELStateUsingAArch32(bits(2) el, boolean secure)
    // See ELStateUsingAArch32K() for description. Must only be called in circumstances where
    // result is valid (typically, that means 'el IN {EL1,EL2,EL3}').
    (known, aarch32) = ELStateUsingAArch32K(el, secure);
    assert known;
    return aarch32;
```

## Library pseudocode for shared/functions/system/ELStateUsingAArch32K

```
// ELStateUsingAArch32K()
// =====

(boolean,boolean) ELStateUsingAArch32K(bits(2) el, boolean secure)
// Returns (known, aarch32):
// 'known' is FALSE for EL0 if the current Exception level is not EL0 and EL1 is
// using AArch64, since it cannot determine the state of EL0; TRUE otherwise.
// 'aarch32' is TRUE if the specified Exception level is using AArch32; FALSE otherwise.
if !HaveAArch32EL(el) then
    return (TRUE, FALSE); // Exception level is using AArch64
elseif secure && el == EL2 then
    return (TRUE, FALSE); // Secure EL2 is using AArch64
elseif HighestELUsingAArch32() then
    return (TRUE, TRUE); // Highest Exception level, and therefore all levels are using AArch32
elseif el == HighestEL() then
    return (TRUE, FALSE); // This is highest Exception level, so is using AArch32

// Remainder of function deals with the interprocessing cases when highest Exception level is using AArch64

boolean aarch32 = boolean UNKNOWN;
boolean known = TRUE;

aarch32_below_el3 = HaveEL(EL3) && SCR_EL3.RW == '0' && (!secure || !HaveSecureEL2Ext() || SCR_EL3.EEL2 == '1')
aarch32_at_el1 = (aarch32_below_el3 || (HaveEL(EL2) && ((HaveSecureEL2Ext() && SCR_EL3.EEL2 == '1') || !secure) && HCR_EL2.E2H == '1' && HCR_EL2.TGE == '1' && HaveVirtHostExt()))
// Only know if EL0 using AArch32 from PSTATE
if el == EL0 && !aarch32_at_el1 then
    if PSTATE.EL == EL0 then
        aarch32 = PSTATE.nRW == '1'; // EL0 controlled by PSTATE
    else
        known = FALSE; // EL0 state is UNKNOWN
else
    aarch32 = (aarch32_below_el3 && el != EL3) || (aarch32_at_el1 && el IN {EL1, EL0});

if !known then aarch32 = boolean UNKNOWN;
return (known, aarch32);
```

## Library pseudocode for shared/functions/system/ELUsingAArch32

```
// ELUsingAArch32()
// =====

boolean ELUsingAArch32(bits(2) el)
    return ELStateUsingAArch32(el, IsSecureBelowEL3());
```

## Library pseudocode for shared/functions/system/ELUsingAArch32K

```
// ELUsingAArch32K()
// =====

(boolean,boolean) ELUsingAArch32K(bits(2) el)
    return ELStateUsingAArch32K(el, IsSecureBelowEL3());
```

## Library pseudocode for shared/functions/system/EndOfInstruction

```
// Terminate processing of the current instruction.
EndOfInstruction();
```

## Library pseudocode for shared/functions/system/EnterLowPowerState

```
// PE enters a low-power state.
EnterLowPowerState();
```

## Library pseudocode for shared/functions/system/EventRegister

```
bits(1) EventRegister;
```

## Library pseudocode for shared/functions/system/ExceptionalOccurrenceTargetState

```
enumeration ExceptionalOccurrenceTargetState {  
    AArch32_NonDebugState,  
    AArch64_NonDebugState,  
    DebugState  
};
```

## Library pseudocode for shared/functions/system/FIQPending

```
// Returns TRUE if there is any pending physical FIQ.  
boolean FIQPending();
```

## Library pseudocode for shared/functions/system/GetPSRFromPSTATE

```
// GetPSRFromPSTATE()  
// =====  
// Return a PSR value which represents the current PSTATE  
  
bits(N) GetPSRFromPSTATE(ExceptionalOccurrenceTargetState targetELState)  
    if UsingAArch32() && (targetELState IN {AArch32_NonDebugState, DebugState}) then  
        assert N == 32;  
    else  
        assert N == 64;  
        bits(N) spsr = Zeros();  
        spsr<31:28> = PSTATE.<N,Z,C,V>;  
        if HavePANExt() then spsr<22> = PSTATE.PAN;  
        spsr<20> = PSTATE.IL;  
        if PSTATE.nRW == '1' then // AArch32 state  
            spsr<27> = PSTATE.Q;  
            spsr<26:25> = PSTATE.IT<1:0>;  
            if HaveSSBSExt() then spsr<23> = PSTATE.SSBS;  
            if HaveDITExt() then  
                if targetELState == AArch32_NonDebugState then  
                    spsr<21> = PSTATE.DIT;  
                else // AArch64_NonDebugState or DebugState  
                    spsr<24> = PSTATE.DIT;  
            if targetELState IN {AArch64_NonDebugState, DebugState} then  
                spsr<21> = PSTATE.SS;  
            spsr<19:16> = PSTATE.GE;  
            spsr<15:10> = PSTATE.IT<7:2>;  
            spsr<9> = PSTATE.E;  
            spsr<8:6> = PSTATE.<A,I,F>; // No PSTATE.D in AArch32 state  
            spsr<5> = PSTATE.T;  
            assert PSTATE.M<4> == PSTATE.nRW; // bit [4] is the discriminator  
            spsr<4:0> = PSTATE.M;  
        else // AArch64 state  
            if HaveMTEExt() then spsr<25> = PSTATE.TC0;  
            if HaveDITExt() then spsr<24> = PSTATE.DIT;  
            if HaveUA0Ext() then spsr<23> = PSTATE.UA0;  
            spsr<21> = PSTATE.SS;  
            if HaveSSBSExt() then spsr<12> = PSTATE.SSBS;  
            if HaveBTIExt() then spsr<11:10> = PSTATE.BTYPE;  
            spsr<9:6> = PSTATE.<D,A,I,F>;  
            spsr<4> = PSTATE.nRW;  
            spsr<3:2> = PSTATE.EL;  
            spsr<0> = PSTATE.SP;  
        return spsr;
```

## Library pseudocode for shared/functions/system/HasArchVersion

```
// HasArchVersion()
// =====
// Returns TRUE if the implemented architecture includes the extensions defined in the specified
// architecture version.

boolean HasArchVersion(ArchVersion version)
    return version == ARMv8p0 || boolean IMPLEMENTATION_DEFINED;
```

## Library pseudocode for shared/functions/system/HaveAArch32EL

```
// HaveAArch32EL()
// =====

boolean HaveAArch32EL(bits(2) el)
    // Return TRUE if Exception level 'el' supports AArch32 in this implementation
    if !HaveEL(el) then
        return FALSE; // The Exception level is not implemented
    elseif !HaveAnyAArch32() then
        return FALSE; // No Exception level can use AArch32
    elseif HighestELUsingAArch32() then
        return TRUE; // All Exception levels are using AArch32
    elseif el == HighestEL() then
        return FALSE; // The highest Exception level is using AArch64
    elseif el == EL0 then
        return TRUE; // EL0 must support using AArch32 if any AArch32
    return boolean IMPLEMENTATION_DEFINED;
```

## Library pseudocode for shared/functions/system/HaveAnyAArch32

```
// HaveAnyAArch32()
// =====
// Return TRUE if AArch32 state is supported at any Exception level.

boolean HaveAnyAArch32()
    return boolean IMPLEMENTATION_DEFINED;
```

## Library pseudocode for shared/functions/system/HaveAnyAArch64

```
// HaveAnyAArch64()
// =====
// Return TRUE if AArch64 state is supported at any Exception level.

boolean HaveAnyAArch64()
    return !HighestELUsingAArch32();
```

## Library pseudocode for shared/functions/system/HaveEL

```
// HaveEL()
// =====
// Return TRUE if Exception level 'el' is supported

boolean HaveEL(bits(2) el)
    if el IN {EL1,EL0} then
        return TRUE; // EL1 and EL0 must exist
    return boolean IMPLEMENTATION_DEFINED;
```



## Library pseudocode for shared/functions/system/HaveELUsingSecurityState

```
// HaveELUsingSecurityState()
// =====
// Returns TRUE if Exception level 'el' with Security state 'secure' is supported,
// FALSE otherwise.

boolean HaveELUsingSecurityState(bits(2) el, boolean secure)

    case el of
        when EL3
            assert secure;
            return HaveEL(EL3);
        when EL2
            if secure then
                return HaveEL(EL2) && HaveSecureEL2Ext();
            else
                return HaveEL(EL2);
        otherwise
            return (HaveEL(EL3) ||
                (secure == boolean IMPLEMENTATION_DEFINED "Secure-only implementation"));
```

## Library pseudocode for shared/functions/system/HaveFP16Ext

```
// HaveFP16Ext()
// =====
// Return TRUE if FP16 extension is supported

boolean HaveFP16Ext()
    return boolean IMPLEMENTATION_DEFINED;
```

## Library pseudocode for shared/functions/system/HighestEL

```
// HighestEL()
// =====
// Returns the highest implemented Exception level.

bits(2) HighestEL()
    if HaveEL(EL3) then
        return EL3;
    elsif HaveEL(EL2) then
        return EL2;
    else
        return EL1;
```

## Library pseudocode for shared/functions/system/HighestELUsingAArch32

```
// HighestELUsingAArch32()
// =====
// Return TRUE if the highest implemented Exception level is using AArch32

boolean HighestELUsingAArch32()
    if !HaveAnyAArch32() then return FALSE;
    return boolean IMPLEMENTATION_DEFINED "Highest EL using AArch32";
```

## Library pseudocode for shared/functions/system/Hint\_DGH

```
// Provides a hint to close any gathering occurring within the micro-architecture.
Hint_DGH();
```

## Library pseudocode for shared/functions/system/Hint\_WFE

```
// Hint_WFE()
// =====
// Provides a hint indicating that the PE can enter a low-power state
// and remain there until a wakeup event occurs or, for WFET, a local
// timeout event is generated when the virtual timer value equals or
// exceeds the supplied threshold value.

Hint_WFE(integer localtimeout, WfxType wfxtype)
    if IsEventRegisterSet() then
        ClearEventRegister();
    else
        trap = FALSE;
        if PSTATE.EL == EL0 then
            // Check for traps described by the OS which may be EL1 or EL2.
            if HaveTWEExt() then
                sctlr = SCTLR[];
                trap = sctlr.nTWE == '0';
                target_el = EL1;
            else
                AArch64.CheckForWfxTrap(EL1, wfxtype);
        if !trap && PSTATE.EL IN {EL0, EL1} && EL2Enabled() && !IsInHost() then
            // Check for traps described by the Hypervisor.
            if HaveTWEExt() then
                trap = HCR_EL2.TWE == '1';
                target_el = EL2;
            else
                AArch64.CheckForWfxTrap(EL2, wfxtype);

        if !trap && HaveEL(EL3) && PSTATE.EL != EL3 then
            // Check for traps described by the Secure Monitor.
            if HaveTWEExt() then
                trap = SCR_EL3.TWE == '1';
                target_el = EL3;
            else
                AArch64.CheckForWfxTrap(EL3, wfxtype);

        if trap && PSTATE.EL != EL3 then
            (delay_enabled, delay) = WFETrapDelay(target_el); // (If trap delay is enabled, Delay amount)
            if !WaitForEventUntilDelay(delay_enabled, delay) then
                // Event did not arrive before delay expired
                AArch64.WfxTrap(wfxtype, target_el); // Trap WFE
        else
            WaitForEvent(localtimeout);
```

## Library pseudocode for shared/functions/system/Hint\_WFI

```
// Hint_WFI()
// =====
// Provides a hint indicating that the PE can enter a low-power state and
// remain there until a wakeup event occurs or, for WFIT, a local timeout
// event is generated when the virtual timer value equals or exceeds the
// supplied threshold value.

Hint_WFI(integer localtimeout, WfxType wfxtype)
    if !InterruptPending() then
        if PSTATE.EL == EL0 then
            // Check for traps described by the OS.
            AArch64.CheckForWfxTrap(EL1, wfxtype);
        if PSTATE.EL IN {EL0, EL1} && EL2Enabled() && !IsInHost() then
            // Check for traps described by the Hypervisor.
            AArch64.CheckForWfxTrap(EL2, wfxtype);
        if HaveEL(EL3) && PSTATE.EL != EL3 then
            // Check for traps described by the Secure Monitor.
            AArch64.CheckForWfxTrap(EL3, wfxtype);
        WaitForInterrupt(localtimeout);
```

## Library pseudocode for shared/functions/system/Hint\_Yield

```
// Provides a hint that the task performed by a thread is of low
// importance so that it could yield to improve overall performance.
Hint_Yield();
```

## Library pseudocode for shared/functions/system/IRQPending

```
// Returns TRUE if there is any pending physical IRQ.
boolean IRQPending();
```

## Library pseudocode for shared/functions/system/IllegalExceptionReturn

```
// IllegalExceptionReturn()
// =====

boolean IllegalExceptionReturn(bits(N) spsr)

    // Check for illegal return:
    // * To an unimplemented Exception level.
    // * To EL2 in Secure state, when SecureEL2 is not enabled.
    // * To EL0 using AArch64 state, with SPSR.M[0]==1.
    // * To AArch64 state with SPSR.M[1]==1.
    // * To AArch32 state with an illegal value of SPSR.M.
    (valid, target) = ELFromSPSR(spsr);
    if !valid then return TRUE;

    // Check for return to higher Exception level
    if UInt(target) > UInt(PSTATE.EL) then return TRUE;

    spsr_mode_is_aarch32 = (spsr<4> == '1');

    // Check for illegal return:
    // * To EL1, EL2 or EL3 with register width specified in the SPSR different from the
    //   Execution state used in the Exception level being returned to, as determined by
    //   the SCR_EL3.RW or HCR_EL2.RW bits, or as configured from reset.
    // * To EL0 using AArch64 state when EL1 is using AArch32 state as determined by the
    //   SCR_EL3.RW or HCR_EL2.RW bits or as configured from reset.
    // * To AArch64 state from AArch32 state (should be caught by above)
    (known, target_el_is_aarch32) = ELUsingAArch32K(target);
    assert known || (target == EL0 && !ELUsingAArch32(EL1));
    if known && spsr_mode_is_aarch32 != target_el_is_aarch32 then return TRUE;

    // Check for illegal return from AArch32 to AArch64
    if UsingAArch32() && !spsr_mode_is_aarch32 then return TRUE;

    // Check for illegal return to EL1 when HCR.TGE is set and when either of
    // * SecureEL2 is enabled.
    // * SecureEL2 is not enabled and EL1 is in Non-secure state.
    if HaveEL(EL2) && target == EL1 && HCR_EL2.TGE == '1' then
        if (!IsSecureBelowEL3() || IsSecureEL2Enabled()) then return TRUE;
    return FALSE;
```

## Library pseudocode for shared/functions/system/InstrSet

```
enumeration InstrSet {InstrSet_A64, InstrSet_A32, InstrSet_T32};
```

## Library pseudocode for shared/functions/system/InstructionSynchronizationBarrier

```
InstructionSynchronizationBarrier();
```

## Library pseudocode for shared/functions/system/InterruptPending

```
// InterruptPending()
// =====
// Returns TRUE if there are any pending physical or virtual
// interrupts, and FALSE otherwise.

boolean InterruptPending()
    bit vIRQstatus = (if VirtualIRQPending\(\) then '1' else '0') OR HCR_EL2.VI;
    bit vFIQstatus = (if VirtualFIQPending\(\) then '1' else '0') OR HCR_EL2.VF;
    bits(3) v_interrupts = HCR_EL2.VSE : vIRQstatus : vFIQstatus;

    pending_physical_interrupt = (IRQPending\(\) || FIQPending\(\) ||
                                  IsPhysicalSErrorPending\(\));
    pending_virtual_interrupt  = !IsInHost\(\) && ((v_interrupts AND
                                                  HCR_EL2.<AMO,IMO,FMO>) != '000');
    return pending_physical_interrupt || pending_virtual_interrupt;
```

## Library pseudocode for shared/functions/system/IsEventRegisterSet

```
// IsEventRegisterSet()
// =====
// Return TRUE if the Event Register of this PE is set, and FALSE if it is clear.

boolean IsEventRegisterSet()
    return EventRegister == '1';
```

## Library pseudocode for shared/functions/system/IsHighestEL

```
// IsHighestEL()
// =====
// Returns TRUE if given exception level is the highest exception level implemented

boolean IsHighestEL(bits(2) el)
    return HighestEL\(\) == el;
```

## Library pseudocode for shared/functions/system/IsInHost

```
// IsInHost()
// =====

boolean IsInHost()
    return ELIsInHost\(\)(PSTATE.EL);
```

## Library pseudocode for shared/functions/system/IsPhysicalSErrorPending

```
// Returns TRUE if a physical SError interrupt is pending.
boolean IsPhysicalSErrorPending();
```

## Library pseudocode for shared/functions/system/IsSErrorEdgeTriggered

```
// IsSErrorEdgeTriggered()
// =====
// Returns TRUE if the physical SError interrupt is edge-triggered
// and FALSE otherwise.

boolean IsSErrorEdgeTriggered(bits(2) target_el, bits(25) syndrome)
    if HaveRASExt() then
        if HaveDoubleFaultExt() then
            return TRUE;

        if ELUsingAArch32(target_el) then
            if syndrome<11:10> != '00' then
                // AArch32 and not Uncontainable.
                return TRUE;
        else
            if syndrome<24> == '0' && syndrome<5:0> != '000000' then
                // AArch64 and neither IMPLEMENTATION_DEFINED syndrome nor Uncategorized.
                return TRUE;
    return boolean IMPLEMENTATION_DEFINED "Edge-triggered SError";
```

## Library pseudocode for shared/functions/system/IsSecure

```
// IsSecure()
// =====
// Returns TRUE if current Exception level is in Secure state.

boolean IsSecure()
    if HaveEL(EL3) && !UsingAArch32() && PSTATE.EL == EL3 then
        return TRUE;
    elseif HaveEL(EL3) && UsingAArch32() && PSTATE.M == M32_Monitor then
        return TRUE;
    return IsSecureBelowEL3();
```

## Library pseudocode for shared/functions/system/IsSecureBelowEL3

```
// IsSecureBelowEL3()
// =====
// Return TRUE if an Exception level below EL3 is in Secure state
// or would be following an exception return to that level.
//
// Differs from IsSecure in that it ignores the current EL or Mode
// in considering security state.
// That is, if at AArch64 EL3 or in AArch32 Monitor mode, whether an
// exception return would pass to Secure or Non-secure state.

boolean IsSecureBelowEL3()
    if HaveEL(EL3) then
        return SCR_GEN[].NS == '0';
    elseif HaveEL(EL2) && (!HaveSecureEL2Ext() || HighestELUsingAArch32()) then
        // If Secure EL2 is not an architecture option then we must be Non-secure.
        return FALSE;
    else
        // TRUE if processor is Secure or FALSE if Non-secure.
        return boolean IMPLEMENTATION_DEFINED "Secure-only implementation";
```

## Library pseudocode for shared/functions/system/IsSecureEL2Enabled

```
// IsSecureEL2Enabled()
// =====
// Returns TRUE if Secure EL2 is enabled, FALSE otherwise.

boolean IsSecureEL2Enabled()
    if HaveEL(EL2) && HaveSecureEL2Ext() then
        if HaveEL(EL3) then
            if !ELUsingAArch32(EL3) && SCR_EL3.EEL2 == '1' then
                return TRUE;
            else
                return FALSE;
        else
            return IsSecure();
    else
        return FALSE;
```

## Library pseudocode for shared/functions/system/IsSynchronizablePhysicalSErrorPending

```
// Returns TRUE if a synchronizable physical SError interrupt is pending.
boolean IsSynchronizablePhysicalSErrorPending();
```

## Library pseudocode for shared/functions/system/IsVirtualSErrorPending

```
// Returns TRUE if a virtual SError interrupt is pending.
boolean IsVirtualSErrorPending();
```

## Library pseudocode for shared/functions/system/LocalTimeoutEvent

```
// Returns TRUE if a local timeout event is generated when the value of
// CNTVCT_EL0 equals or exceeds the threshold value for the first time.
// If the threshold value is less than zero a local timeout event will
// not be generated.
boolean LocalTimeoutEvent(integer localtimeout);
```

## Library pseudocode for shared/functions/system/Mode\_Bits

```
constant bits(5) M32_User      = '10000';
constant bits(5) M32_FIQ      = '10001';
constant bits(5) M32_IRQ      = '10010';
constant bits(5) M32_Svc      = '10011';
constant bits(5) M32_Monitor  = '10110';
constant bits(5) M32_Abort    = '10111';
constant bits(5) M32_Hyp      = '11010';
constant bits(5) M32_Undef    = '11011';
constant bits(5) M32_System   = '11111';
```

## Library pseudocode for shared/functions/system/PL0fEL

```
// PL0fEL()
// =====

PrivilegeLevel PL0fEL(bits(2) el)
    case el of
        when EL3 return if HighestELUsingAArch32() then PL1 else PL3;
        when EL2 return PL2;
        when EL1 return PL1;
        when EL0 return PL0;
```

## Library pseudocode for shared/functions/system/PSTATE

```
ProcState PSTATE;
```

## Library pseudocode for shared/functions/system/PhysicalCountInt

```
// Returns the integral part of physical count value of the System counter.
bits(64) PhysicalCountInt();
```

## Library pseudocode for shared/functions/system/PrivilegeLevel

```
enumeration PrivilegeLevel {PL3, PL2, PL1, PL0};
```

## Library pseudocode for shared/functions/system/ProcState

```
type ProcState is (
    bits (1) N,          // Negative condition flag
    bits (1) Z,          // Zero condition flag
    bits (1) C,          // Carry condition flag
    bits (1) V,          // oVerflow condition flag
    bits (1) D,          // Debug mask bit [AArch64 only]
    bits (1) A,          // SError interrupt mask bit
    bits (1) I,          // IRQ mask bit
    bits (1) F,          // FIQ mask bit
    bits (1) PAN,        // Privileged Access Never Bit [v8.1]
    bits (1) UAO,        // User Access Override [v8.2]
    bits (1) DIT,        // Data Independent Timing [v8.4]
    bits (1) TCO,        // Tag Check Override [v8.5, AArch64 only]
    bits (2) BTYPE,      // Branch Type [v8.5]
    bits (1) SS,         // Software step bit
    bits (1) IL,         // Illegal Execution state bit
    bits (2) EL,         // Exception level
    bits (1) nRW,        // not Register Width: 0=64, 1=32
    bits (1) SP,         // Stack pointer select: 0=SP0, 1=SPx [AArch64 only]
    bits (1) Q,          // Cumulative saturation flag [AArch32 only]
    bits (4) GE,         // Greater than or Equal flags [AArch32 only]
    bits (1) SSBS,       // Speculative Store Bypass Safe
    bits (8) IT,         // If-then bits, RES0 in CPSR [AArch32 only]
    bits (1) J,          // J bit, RES0 [AArch32 only, RES0 in SPSR and CPSR]
    bits (1) T,          // T32 bit, RES0 in CPSR [AArch32 only]
    bits (1) E,          // Endianness bit [AArch32 only]
    bits (5) M           // Mode field [AArch32 only]
)
```

## Library pseudocode for shared/functions/system/RestoredITBits

```
// RestoredITBits()
// =====
// Get the value of PSTATE.IT to be restored on this exception return.

bits(8) RestoredITBits(bits(N) spsr)
    it = spsr<15:10,26:25>;

    // When PSTATE.IL is set, it is CONSTRAINED UNPREDICTABLE whether the IT bits are each set
    // to zero or copied from the SPSR.
    if PSTATE.IL == '1' then
        if ConstrainUnpredictableBool\(Unpredictable\_ILZER0IT\) then return '00000000';
        else return it;

    // The IT bits are forced to zero when they are set to a reserved value.
    if !IsZero(it<7:4>) && IsZero(it<3:0>) then
        return '00000000';

    // The IT bits are forced to zero when returning to A32 state, or when returning to an EL
    // with the ITD bit set to 1, and the IT bits are describing a multi-instruction block.
    itd = if PSTATE.EL == EL2 then HSCTLR.ITD else SCTLR.ITD;
    if (spsr<5> == '0' && !IsZero(it)) || (itd == '1' && !IsZero(it<2:0>)) then
        return '00000000';
    else
        return it;
```

## Library pseudocode for shared/functions/system/SCRType

```
type SCRType;
```

## Library pseudocode for shared/functions/system/SCR\_GEN

```
// SCR_GEN[]  
// =====  
  
SCRType SCR_GEN[]  
    // AArch32 secure & AArch64 EL3 registers are not architecturally mapped  
    assert HaveEL(EL3);  
    bits(64) r;  
    if HighestELUsingAArch32() then  
        r = ZeroExtend(SCR);  
    else  
        r = SCR_EL3;  
    return r;
```

## Library pseudocode for shared/functions/system/SecurityState

```
enumeration SecurityState {  
    SS_NonSecure,  
    SS_Secure  
};
```

## Library pseudocode for shared/functions/system/SendEvent

```
// Signal an event to all PEs in a multiprocessor system to set their Event Registers.  
// When a PE executes the SEV instruction, it causes this function to be executed.  
SendEvent();
```

## Library pseudocode for shared/functions/system/SendEventLocal

```
// SendEventLocal()  
// =====  
// Set the local Event Register of this PE.  
// When a PE executes the SEVL instruction, it causes this function to be executed.  
  
SendEventLocal()  
    EventRegister = '1';  
    return;
```



## Library pseudocode for shared/functions/system/SetPSTATEFromPSR

```
// SetPSTATEFromPSR()
// =====
// Set PSTATE based on a PSR value

SetPSTATEFromPSR(bits(N) spsr)
    boolean from_aarch64 = !UsingAArch32();
    assert N == (if from_aarch64 then 64 else 32);
    PSTATE.SS = DebugExceptionReturnSS(spsr);
    ShouldAdvanceSS = FALSE;
    if IllegalExceptionReturn(spsr) then
        PSTATE.IL = '1';
        if HaveSSBSExt() then PSTATE.SSBS = bit UNKNOWN;
        if HaveBTIExt() then PSTATE.BTYPE = bits(2) UNKNOWN;
        if HaveUA0Ext() then PSTATE.UA0 = bit UNKNOWN;
        if HaveDITExt() then PSTATE.DIT = bit UNKNOWN;
        if HaveMTEExt() then PSTATE.TCO = bit UNKNOWN;
    else
        // State that is reinstated only on a legal exception return
        PSTATE.IL = spsr<20>;
        if spsr<4> == '1' then // AArch32 state
            AArch32.WriteMode(spsr<4:0>); // Sets PSTATE.EL correctly
            if HaveSSBSExt() then PSTATE.SSBS = spsr<23>;
        else // AArch64 state
            PSTATE.nRW = '0';
            PSTATE.EL = spsr<3:2>;
            PSTATE.SP = spsr<0>;
            if HaveBTIExt() then PSTATE.BTYPE = spsr<11:10>;
            if HaveSSBSExt() then PSTATE.SSBS = spsr<12>;
            if HaveUA0Ext() then PSTATE.UA0 = spsr<23>;
            if HaveDITExt() then PSTATE.DIT = spsr<24>;
            if HaveMTEExt() then PSTATE.TCO = spsr<25>;

        // If PSTATE.IL is set and returning to AArch32 state, it is CONSTRAINED UNPREDICTABLE whether
        // the T bit is set to zero or copied from SPSR.
        if PSTATE.IL == '1' && PSTATE.nRW == '1' then
            if ConstrainUnpredictableBool(Unpredictable_ILZEROT) then spsr<5> = '0';

        // State that is reinstated regardless of illegal exception return
        PSTATE.<N,Z,C,V> = spsr<31:28>;
        if HavePANExt() then PSTATE.PAN = spsr<22>;
        if PSTATE.nRW == '1' then // AArch32 state
            PSTATE.Q = spsr<27>;
            PSTATE.IT = RestoredITBits(spsr);
            ShouldAdvanceIT = FALSE;
            if HaveDITExt() then PSTATE.DIT = (if (Restarting() || from_aarch64) then spsr<24> else spsr<21>);
            PSTATE.GE = spsr<19:16>;
            PSTATE.E = spsr<9>;
            PSTATE.<A,I,F> = spsr<8:6>; // No PSTATE.D in AArch32 state
            PSTATE.T = spsr<5>; // PSTATE.J is RES0
        else // AArch64 state
            // No PSTATE.<Q,IT,GE,E,T> in AArch64 state
            PSTATE.<D,A,I,F> = spsr<9:6>;
        return;
```

## Library pseudocode for shared/functions/system/ShouldAdvanceIT

```
boolean ShouldAdvanceIT;
```

## Library pseudocode for shared/functions/system/ShouldAdvanceSS

```
boolean ShouldAdvanceSS;
```

## Library pseudocode for shared/functions/system/SpeculationBarrier

```
SpeculationBarrier();
```

### Library pseudocode for shared/functions/system/SynchronizeContext

```
SynchronizeContext();
```

### Library pseudocode for shared/functions/system/SynchronizeErrors

```
// Implements the error synchronization event.  
SynchronizeErrors();
```

### Library pseudocode for shared/functions/system/TakeUnmaskedPhysicalSErrorInterrupts

```
// Take any pending unmasked physical SError interrupt.  
TakeUnmaskedPhysicalSErrorInterrupts(boolean iesb_req);
```

### Library pseudocode for shared/functions/system/TakeUnmaskedSErrorInterrupts

```
// Take any pending unmasked physical SError interrupt or unmasked virtual SError  
// interrupt.  
TakeUnmaskedSErrorInterrupts();
```

### Library pseudocode for shared/functions/system/ThisInstr

```
bits(32) ThisInstr();
```

### Library pseudocode for shared/functions/system/ThisInstrLength

```
integer ThisInstrLength();
```

### Library pseudocode for shared/functions/system/Unreachable

```
Unreachable()  
    assert FALSE;
```

### Library pseudocode for shared/functions/system/UsingAArch32

```
// UsingAArch32()  
// =====  
// Return TRUE if the current Exception level is using AArch32, FALSE if using AArch64.  
  
boolean UsingAArch32()  
    boolean aarch32 = (PSTATE.nRW == '1');  
    if !HaveAnyAArch32() then assert !aarch32;  
    if HighestELUsingAArch32() then assert aarch32;  
    return aarch32;
```

### Library pseudocode for shared/functions/system/VirtualFIQPending

```
// Returns TRUE if there is any pending virtual FIQ.  
boolean VirtualFIQPending();
```

### Library pseudocode for shared/functions/system/VirtualIRQPending

```
// Returns TRUE if there is any pending virtual IRQ.  
boolean VirtualIRQPending();
```

### Library pseudocode for shared/functions/system/WFxType

```
enumeration WFxType {WfxType_WFE, WfxType_WFI, WfxType_WFET, WfxType_WFIT};
```

## Library pseudocode for shared/functions/system/WaitForEvent

```
// WaitForEvent()
// =====
// PE optionally suspends execution until one of the following occurs:
// - A WFE wake-up event.
// - A reset.
// - The implementation chooses to resume execution.
// - A Wait for Event with Timeout (WFET) is executing, and a local timeout event occurs
// It is IMPLEMENTATION DEFINED whether restarting execution after the period of
// suspension causes the Event Register to be cleared.

WaitForEvent(integer localtimeout)
    if !(IsEventRegisterSet() || LocalTimeoutEvent(localtimeout)) then
        EnterLowPowerState();
    return;
```

## Library pseudocode for shared/functions/system/WaitForInterrupt

```
// WaitForInterrupt()
// =====
// PE optionally suspends execution until one of the following occurs:
// - A WFI wake-up event.
// - A reset.
// - The implementation chooses to resume execution.
// - A Wait for Interrupt with Timeout (WFIT) is executing, and a local timeout event occurs.

WaitForInterrupt(integer localtimeout)
    if localtimeout < 0 then
        EnterLowPowerState();
    else
        if !LocalTimeoutEvent(localtimeout) then
            EnterLowPowerState();
    return;
```



```
// ConstrainUnpredictable()
// =====
// Return the appropriate Constraint result to control the caller's behavior. The return value
// is IMPLEMENTATION DEFINED within a permitted list for each UNPREDICTABLE case.
// (The permitted list is determined by an assert or case statement at the call site.)

// NOTE: This version of the function uses an Unpredictable argument to define the call site.
// This argument does not appear in the version used in the Armv8 Architecture Reference Manual.
// The extra argument is used here to allow this example definition. This is an example only and
// does not imply a fixed implementation of these behaviors. Indeed the intention is that it should
// be defined by each implementation, according to its implementation choices.
```

```
Constraint ConstrainUnpredictable(Unpredictable which)
    case which of
        when Unpredictable\_VMSR
            return Constraint\_UNDEF;
        when Unpredictable\_WBOVERLAPLD
            return Constraint\_WBSUPPRESS; // return loaded value
        when Unpredictable\_WBOVERLAPST
            return Constraint\_NONE; // store pre-writeback value
        when Unpredictable\_LDPOVERLAP
            return Constraint\_UNDEF; // instruction is UNDEFINED
        when Unpredictable\_BASEOVERLAP
            return Constraint\_NONE; // use original address
        when Unpredictable\_DATAOVERLAP
            return Constraint\_NONE; // store original value
        when Unpredictable\_DEVPAGE2
            return Constraint\_FAULT; // take an alignment fault
        when Unpredictable\_DEVICETAGSTORE
            return Constraint\_NONE; // Do not take a fault
        when Unpredictable\_INSTRDEVICE
            return Constraint\_NONE; // Do not take a fault
        when Unpredictable\_RESCPACR
            return Constraint\_TRUE; // Map to UNKNOWN value
        when Unpredictable\_RESMAIR
            return Constraint\_UNKNOWN; // Map to UNKNOWN value
        when Unpredictable\_S1CTAGGED
            return Constraint\_FALSE; // SCTLRL_ELx.C == '0' marks address as untagged
        when Unpredictable\_S2RESMEMATTR
            return Constraint\_NC; // Map to Noncacheable value
        when Unpredictable\_RESTEXCB
            return Constraint\_UNKNOWN; // Map to UNKNOWN value
        when Unpredictable\_RESDACR
            return Constraint\_UNKNOWN; // Map to UNKNOWN value
        when Unpredictable\_RESPRRR
            return Constraint\_UNKNOWN; // Map to UNKNOWN value
        when Unpredictable\_RESVTCRS
            return Constraint\_UNKNOWN; // Map to UNKNOWN value
        when Unpredictable\_RESTnSZ
            return Constraint\_FORCE; // Map to the limit value
        when Unpredictable\_OORTnSZ
            return Constraint\_FORCE; // Map to the limit value
        when Unpredictable\_LARGEIPA
            return Constraint\_FORCE; // Restrict the IA size to the PAMax value
        when Unpredictable\_ESRCONDPASS
            return Constraint\_FALSE; // Report as "AL"
        when Unpredictable\_ILZEROIT
            return Constraint\_FALSE; // Do not zero PSTATE.IT
        when Unpredictable\_ILZEROT
            return Constraint\_FALSE; // Do not zero PSTATE.T
        when Unpredictable\_BPVECTORCATCHPRI
            return Constraint\_TRUE; // Debug Vector Catch: match on 2nd halfword
        when Unpredictable\_VCMATCHHALF
            return Constraint\_FALSE; // No match
        when Unpredictable\_VCMATCHDAPA
            return Constraint\_FALSE; // No match on Data Abort or Prefetch abort
        when Unpredictable\_WPMASKANDBAS
            return Constraint\_FALSE; // Watchpoint disabled
        when Unpredictable\_WPBASCONTIGUOUS
            return Constraint\_FALSE; // Watchpoint disabled
```

```

when Unpredictable_RESWPMASK
    return Constraint_DISABLED; // Watchpoint disabled
when Unpredictable_WPMASKEDBITS
    return Constraint_FALSE; // Watchpoint disabled
when Unpredictable_RESBPWPCTRL
    return Constraint_DISABLED; // Breakpoint/watchpoint disabled
when Unpredictable_BPNOTIMPL
    return Constraint_DISABLED; // Breakpoint disabled
when Unpredictable_RESBPTYPE
    return Constraint_DISABLED; // Breakpoint disabled
when Unpredictable_BPNOTCTXCMP
    return Constraint_DISABLED; // Breakpoint disabled
when Unpredictable_BPMATCHHALF
    return Constraint_FALSE; // No match
when Unpredictable_BPMISMATCHHALF
    return Constraint_FALSE; // No match
when Unpredictable_RESTARTALIGNPC
    return Constraint_FALSE; // Do not force alignment
when Unpredictable_RESTARTZEROUPPERPC
    return Constraint_TRUE; // Force zero extension
when Unpredictable_ZEROUPPER
    return Constraint_TRUE; // zero top halves of X registers
when Unpredictable_ERETZEROUPPERPC
    return Constraint_TRUE; // zero top half of PC
when Unpredictable_A32FORCEALIGNPC
    return Constraint_FALSE; // Do not force alignment
when Unpredictable_SMD
    return Constraint_UNDEF; // disabled SMC is Unallocated
when Unpredictable_NONFAULT
    return Constraint_FALSE; // Speculation enabled
when Unpredictable_SVEZEROUPPER
    return Constraint_TRUE; // zero top bits of Z registers
when Unpredictable_SVELDNFDATA
    return Constraint_TRUE; // Load mem data in NF loads
when Unpredictable_SVELDNFZERO
    return Constraint_TRUE; // Write zeros in NF loads
when Unpredictable_CHECKSPNONEACTIVE
    return Constraint_TRUE; // Check SP alignment
when Unpredictable_NVNV1
    return Constraint_NVNV1_00; // Map unpredictable configuration of HCR_EL2<NV,NV1>
    // to NV = 0 and NV1 = 0
when Unpredictable_Shareability
    return Constraint_OSH; // Map reserved encoding of shareability to outer shareable
when Unpredictable_AFUPDATE
    return Constraint_TRUE; // AF update for alignment or permission fault
when Unpredictable_IESBinDebug
    return Constraint_TRUE; // Use SCTLR[].IESB in Debug state
when Unpredictable_BADPMSFCR
    return Constraint_TRUE; // Bad settings for PMSFCR_EL1/PMSEVFR_EL1/PMSLATFR_EL1
when Unpredictable_ZEROBTYP
    return Constraint_TRUE; // Save BTYPE in SPSR_ELx/DPSR_EL0 as '00'
when Unpredictable_CLEARERRITEZERO
    return Constraint_FALSE; // Clearing sticky errors when instruction in flight
when Unpredictable_ALUEXCEPTIONRETURN
    return Constraint_UNDEF;
when Unpredictable_DBGxVR_RESS
    return Constraint_FALSE;
when Unpredictable_PMSCR_PCT
    return Constraint_PMSCR_PCT_VIRT;
when Unpredictable_WFXTDEBUG
    return Constraint_FALSE; // WFXT in Debug state does not execute as a NOP
when Unpredictable_LS64UNSUPPORTED
    return Constraint_LIMITED_ATOMICITY; // Accesses are not single-copy atomic above the byte level
// Misaligned exclusives, atomics, acquire/release to region that is not Normal Cacheable WB are a
when Unpredictable_MISALIGNEDATOMIC
    return Constraint_FALSE;

when Unpredictable_IGNORETRAPINDEBUG
    return Constraint_TRUE; // Trap to register access in debug state is ignored

```

```

when Unpredictable\_PMUEVENTCOUNTER
return Constraint\_UNDEF;    // Accesses to the register are UNDEFINED

```

## Library pseudocode for shared/functions/unpredictable/ConstrainUnpredictableBits

```

// ConstrainUnpredictableBits()
// =====

// This is a variant of ConstrainUnpredictable for when the result can be Constraint_UNKNOWN.
// If the result is Constraint_UNKNOWN then the function also returns UNKNOWN value, but that
// value is always an allocated value; that is, one for which the behavior is not itself
// CONSTRAINED.

// NOTE: This version of the function uses an Unpredictable argument to define the call site.
// This argument does not appear in the version used in the Armv8 Architecture Reference Manual.
// See the NOTE on ConstrainUnpredictable() for more information.

// This is an example placeholder only and does not imply a fixed implementation of the bits part
// of the result, and may not be applicable in all cases.

(Constraint,bits(width)) ConstrainUnpredictableBits(Unpredictable which)

    c = ConstrainUnpredictable(which);

    if c == Constraint\_UNKNOWN then
        return (c, Zeros(width));    // See notes; this is an example implementation only
    elsif c == Constraint\_PMSCR\_PCT\_VIRT then
        return (c,Zeros(width));
    else
        return (c, bits(width) UNKNOWN);    // bits result not used

```

## Library pseudocode for shared/functions/unpredictable/ConstrainUnpredictableBool

```

// ConstrainUnpredictableBool()
// =====

// This is a simple wrapper function for cases where the constrained result is either TRUE or FALSE.

// NOTE: This version of the function uses an Unpredictable argument to define the call site.
// This argument does not appear in the version used in the Armv8 Architecture Reference Manual.
// See the NOTE on ConstrainUnpredictable() for more information.

boolean ConstrainUnpredictableBool(Unpredictable which)

    c = ConstrainUnpredictable(which);
    assert c IN {Constraint\_TRUE, Constraint\_FALSE};
    return (c == Constraint\_TRUE);

```

## Library pseudocode for shared/functions/unpredictable/ConstrainUnpredictableInteger

```
// ConstrainUnpredictableInteger()
// =====

// This is a variant of ConstrainUnpredictable for when the result can be Constraint_UNKNOWN. If
// the result is Constraint_UNKNOWN then the function also returns an UNKNOWN value in the range
// low to high, inclusive.

// NOTE: This version of the function uses an Unpredictable argument to define the call site.
// This argument does not appear in the version used in the Armv8 Architecture Reference Manual.
// See the NOTE on ConstrainUnpredictable() for more information.

// This is an example placeholder only and does not imply a fixed implementation of the integer part
// of the result.

(Constraint,integer) ConstrainUnpredictableInteger(integer low, integer high, Unpredictable which)

    c = ConstrainUnpredictable(which);

    if c == Constraint\_UNKNOWN then
        return (c, low);          // See notes; this is an example implementation only
    else
        return (c, integer UNKNOWN); // integer result not used
```

## Library pseudocode for shared/functions/unpredictable/Constraint

```
enumeration Constraint    { // General
    Constraint_NONE,      // Instruction executes with
                          // no change or side-effect to its described b
    Constraint_UNKNOWN,   // Destination register has UNKNOWN value
    Constraint_UNDEF,     // Instruction is UNDEFINED
    Constraint_UNDEFEL0,  // Instruction is UNDEFINED at EL0 only
    Constraint_NOP,       // Instruction executes as NOP
    Constraint_TRUE,
    Constraint_FALSE,
    Constraint_DISABLED,
    Constraint_UNCOND,    // Instruction executes unconditionally
    Constraint_COND,      // Instruction executes conditionally
    Constraint_ADDITIONAL_DECODE, // Instruction executes with additional decode
    // Load-store
    Constraint_WBSUPPRESS,
    Constraint_FAULT,
    Constraint_LIMITED_ATOMICITY, // Accesses are not single-copy atomic above the
    Constraint_NVNV1_00,
    Constraint_NVNV1_01,
    Constraint_NVNV1_11,
    Constraint_OSH,        // Constrain to Outer shareable
    Constraint_ISH,        // Constrain to Inner shareable
    Constraint_NSH,        // Constrain to Nonshareable

    Constraint_NC,         // Constrain to Noncacheable
    Constraint_WT,         // Constrain to Writethrough
    Constraint_WB,         // Constrain to Writeback

    // IPA too large
    Constraint_FORCE, Constraint_FORCENOSLCHECK,
    // PMSCR_PCT reserved values select Virtual timestamp
    Constraint_PMSCR_PCT_VIRT};
```





```

enumeration Unpredictable { // VMSR on MVFR
    Unpredictable_VMSR,
    // Writeback/transfer register overlap (load)
    Unpredictable_WBOVERLAPLD,
    // Writeback/transfer register overlap (store)
    Unpredictable_WBOVERLAPST,
    // Load Pair transfer register overlap
    Unpredictable_LDPOVERLAP,
    // Store-exclusive base/status register overlap
    Unpredictable_BASEOVERLAP,
    // Store-exclusive data/status register overlap
    Unpredictable_DATAOVERLAP,
    // Load-store alignment checks
    Unpredictable_DEVPAGE2,
    // Instruction fetch from Device memory
    Unpredictable_INSTRDEVICE,
    // Reserved CPACR value
    Unpredictable_RESCPACR,
    // Reserved MAIR value
    Unpredictable_RESMAIR,
    // Effect of SCTLR_ELx.C on Tagged attribute
    Unpredictable_S1CTAGGED,
    // Reserved Stage 2 MemAttr value
    Unpredictable_S2RESMEMATTR,
    // Reserved TEX:C:B value
    Unpredictable_RESTEXCB,
    // Reserved PRRR value
    Unpredictable_RESPPRR,
    // Reserved DACR field
    Unpredictable_RESDACR,
    // Reserved VTCR.S value
    Unpredictable_RESVTCRS,
    // Reserved TCR.TnSZ value
    Unpredictable_RESTnSZ,
    // Reserved SCTLR_ELx.TCF value
    Unpredictable_RESTCF,
    // Tag stored to Device memory
    Unpredictable_DEVICETAGSTORE,
    // Out-of-range TCR.TnSZ value
    Unpredictable_0ORTnSZ,
    // IPA size exceeds PA size
    Unpredictable_LARGEIPA,
    // Syndrome for a known-passing conditional A32 instruction
    Unpredictable_ESRCONDPASS,
    // Illegal State exception: zero PSTATE.IT
    Unpredictable_ILZEROIT,
    // Illegal State exception: zero PSTATE.T
    Unpredictable_ILZEROT,
    // Debug: prioritization of Vector Catch
    Unpredictable_BPVECTORCATCHPRI,
    // Debug Vector Catch: match on 2nd halfword
    Unpredictable_VCMATCHHALF,
    // Debug Vector Catch: match on Data Abort or Prefetch abort
    Unpredictable_VCMATCHDAPA,
    // Debug watchpoints: non-zero MASK and non-ones BAS
    Unpredictable_WPMASKANDBAS,
    // Debug watchpoints: non-contiguous BAS
    Unpredictable_WPBASCONTIGUOUS,
    // Debug watchpoints: reserved MASK
    Unpredictable_RESWPMASK,
    // Debug watchpoints: non-zero MASKed bits of address
    Unpredictable_WPMASKEDBITS,
    // Debug breakpoints and watchpoints: reserved control bits
    Unpredictable_RESBPWPCTRL,
    // Debug breakpoints: not implemented
    Unpredictable_BPNOTIMPL,
    // Debug breakpoints: reserved type
    Unpredictable_RESBPTYPE,
    // Debug breakpoints: not-context-aware breakpoint
    Unpredictable_BPNOTCTXCMP,

```

```

// Debug breakpoints: match on 2nd halfword of instruction
Unpredictable_BPMATCHHALF,
// Debug breakpoints: mismatch on 2nd halfword of instruction
Unpredictable_BPMISMATCHHALF,
// Debug: restart to a misaligned AArch32 PC value
Unpredictable_RESTARTALIGNPC,
// Debug: restart to a not-zero-extended AArch32 PC value
Unpredictable_RESTARTZEROUPPERPC,
// Zero top 32 bits of X registers in AArch32 state
Unpredictable_ZEROUPPER,
// Zero top 32 bits of PC on illegal return to AArch32 state
Unpredictable_ERETZEROUPPERPC,
// Force address to be aligned when interworking branch to A32 state
Unpredictable_A32FORCEALIGNPC,
// SMC disabled
Unpredictable_SMD,
// FF speculation
Unpredictable_NONFAULT,
// Zero top bits of Z registers in EL change
Unpredictable_SVEZEROUPPER,
// Load mem data in NF loads
Unpredictable_SVELDNFDATA,
// Write zeros in NF loads
Unpredictable_SVELDNFZERO,
// SP alignment fault when predicate is all zero
Unpredictable_CHECKSPNONEACTIVE,
// HCR_EL2.<NV,NV1> == '01'
Unpredictable_NVNV1,
// Reserved shareability encoding
Unpredictable_Shareability,
// Access Flag Update by HW
Unpredictable_AFUPDATE,
// Consider SCTLR[].IESB in Debug state
Unpredictable_IESBinDebug,
// Bad settings for PMSFCR_EL1/PMSEVFR_EL1/PMSLATFR_EL1
Unpredictable_BADPMSFCR,
// Zero saved BType value in SPSR_ELx/DPSR_EL0
Unpredictable_ZEROBTYPE,
// Timestamp constrained to virtual or physical
Unpredictable_EL2TIMESTAMP,
Unpredictable_EL1TIMESTAMP,
// WFET or WFIT instruction in Debug state
Unpredictable_WFXTDEBUG,
// Address does not support LS64 instructions
Unpredictable_LS64UNSUPPORTED,
// Misaligned exclusives, atomics, acquire/release to region that is not Normal
Unpredictable_MISALIGNEDATOMIC,
// Clearing DCC/ITR sticky flags when instruction is in flight
Unpredictable_CLEARERRITEZERO,
// ALUEXCEPTIONRETURN when in user/system mode in A32 instructions
Unpredictable_ALUEXCEPTIONRETURN,
// Trap to register in debug state are ignored
Unpredictable_IGNORETRAPINDEBUG,
// Compare DBGxVR.RESS for BP/WP
Unpredictable_DBGxVR_RESS,
// Inaccessible event counter
Unpredictable_PMUEVENTCOUNTER,
// Reserved PMSCR.PCT behaviour.
Unpredictable_PMSCR_PCT};

```

## Library pseudocode for shared/functions/vector/AdvSIMDEExpandImm

```
// AdvSIMDEExpandImm()
// =====

bits(64) AdvSIMDEExpandImm(bit op, bits(4) cmode, bits(8) imm8)
  case cmode<3:1> of
    when '000'
      imm64 = Replicate(Zeros(24):imm8, 2);
    when '001'
      imm64 = Replicate(Zeros(16):imm8:Zeros(8), 2);
    when '010'
      imm64 = Replicate(Zeros(8):imm8:Zeros(16), 2);
    when '011'
      imm64 = Replicate(imm8:Zeros(24), 2);
    when '100'
      imm64 = Replicate(Zeros(8):imm8, 4);
    when '101'
      imm64 = Replicate(imm8:Zeros(8), 4);
    when '110'
      if cmode<0> == '0' then
        imm64 = Replicate(Zeros(16):imm8:Ones(8), 2);
      else
        imm64 = Replicate(Zeros(8):imm8:Ones(16), 2);
    when '111'
      if cmode<0> == '0' && op == '0' then
        imm64 = Replicate(imm8, 8);
      if cmode<0> == '0' && op == '1' then
        imm8a = Replicate(imm8<7>, 8); imm8b = Replicate(imm8<6>, 8);
        imm8c = Replicate(imm8<5>, 8); imm8d = Replicate(imm8<4>, 8);
        imm8e = Replicate(imm8<3>, 8); imm8f = Replicate(imm8<2>, 8);
        imm8g = Replicate(imm8<1>, 8); imm8h = Replicate(imm8<0>, 8);
        imm64 = imm8a:imm8b:imm8c:imm8d:imm8e:imm8f:imm8g:imm8h;
      if cmode<0> == '1' && op == '0' then
        imm32 = imm8<7>:NOT(imm8<6>):Replicate(imm8<6>,5):imm8<5:0>:Zeros(19);
        imm64 = Replicate(imm32, 2);
      if cmode<0> == '1' && op == '1' then
        if UsingAArch32() then ReservedEncoding();
        imm64 = imm8<7>:NOT(imm8<6>):Replicate(imm8<6>,8):imm8<5:0>:Zeros(48);

  return imm64;
```

## Library pseudocode for shared/functions/vector/MatMulAdd

```
// MatMulAdd()
// =====
//
// Signed or unsigned 8-bit integer matrix multiply and add to 32-bit integer matrix
// result[2, 2] = addend[2, 2] + (op1[2, 8] * op2[8, 2])

bits(N) MatMulAdd(bits(N) addend, bits(N) op1, bits(N) op2, boolean op1_unsigned, boolean op2_unsigned)
  assert N == 128;

  bits(N) result;
  bits(32) sum;
  integer prod;

  for i = 0 to 1
    for j = 0 to 1
      sum = Elem[addend, 2*i + j, 32];
      for k = 0 to 7
        prod = Int(Elem[op1, 8*i + k, 8], op1_unsigned) * Int(Elem[op2, 8*j + k, 8], op2_unsigned)
        sum = sum + prod;
      Elem[result, 2*i + j, 32] = sum;

  return result;
```

## Library pseudocode for shared/functions/vector/PolynomialMult

```
// PolynomialMult()
// =====

bits(M+N) PolynomialMult(bits(M) op1, bits(N) op2)
    result = Zeros(M+N);
    extended_op2 = ZeroExtend(op2, M+N);
    for i=0 to M-1
        if op1<i> == '1' then
            result = result EOR LSL(extended_op2, i);
    return result;
```

## Library pseudocode for shared/functions/vector/SatQ

```
// SatQ()
// =====

(bits(N), boolean) SatQ(integer i, integer N, boolean unsigned)
    (result, sat) = if unsigned then UnsignedSatQ(i, N) else SignedSatQ(i, N);
    return (result, sat);
```

## Library pseudocode for shared/functions/vector/SignedSatQ

```
// SignedSatQ()
// =====

(bits(N), boolean) SignedSatQ(integer i, integer N)
    if i > 2^(N-1) - 1 then
        result = 2^(N-1) - 1; saturated = TRUE;
    elsif i < -(2^(N-1)) then
        result = -(2^(N-1)); saturated = TRUE;
    else
        result = i; saturated = FALSE;
    return (result<N-1:0>, saturated);
```

## Library pseudocode for shared/functions/vector/UnsignedRSqrtEstimate

```
// UnsignedRSqrtEstimate()
// =====

bits(N) UnsignedRSqrtEstimate(bits(N) operand)
    assert N == 32;
    if operand<N-1:N-2> == '00' then // Operands <= 0x3FFFFFFF produce 0xFFFFFFFF
        result = Ones(N);
    else
        // input is in the range 0x40000000 .. 0xffffffff representing [0.25 .. 1.0)
        // estimate is in the range 256 .. 511 representing [1.0 .. 2.0)
        increasedprecision = FALSE;
        estimate = RecipSqrtEstimate(UInt(operand<31:23>), increasedprecision);
        // result is in the range 0x80000000 .. 0xff800000 representing [1.0 .. 2.0)
        result = estimate<8:0> : Zeros(N-9);

    return result;
```

## Library pseudocode for shared/functions/vector/UnsignedRecipEstimate

```
// UnsignedRecipEstimate()
// =====

bits(N) UnsignedRecipEstimate(bits(N) operand)
    assert N == 32;
    if operand<N-1> == '0' then // Operands <= 0x7FFFFFFF produce 0xFFFFFFFF
        result = Ones(N);
    else
        // input is in the range 0x80000000 .. 0xffffffff representing [0.5 .. 1.0)

        // estimate is in the range 256 to 511 representing [1.0 .. 2.0)
        increasedprecision = FALSE;
        estimate = RecipEstimate(UInt(operand<31:23>), increasedprecision);

        // result is in the range 0x80000000 .. 0xff800000 representing [1.0 .. 2.0)
        result = estimate<8:0> : Zeros(N-9);

    return result;
```

## Library pseudocode for shared/functions/vector/UnsignedSatQ

```
// UnsignedSatQ()
// =====

(bits(N), boolean) UnsignedSatQ(integer i, integer N)
    if i > 2^N - 1 then
        result = 2^N - 1; saturated = TRUE;
    elsif i < 0 then
        result = 0; saturated = TRUE;
    else
        result = i; saturated = FALSE;
    return (result<N-1:0>, saturated);
```

## Library pseudocode for shared/trace/selfhosted/SelfHostedTraceEnabled

```
// SelfHostedTraceEnabled()
// =====
// Returns TRUE if Self-hosted Trace is enabled.

boolean SelfHostedTraceEnabled()
    if !HaveTraceExt() || !HaveSelfHostedTrace() then return FALSE;
    if HaveEL(EL3) then
        secure_trace_enable = (if ELUsingAArch32(EL3) then SDCR.STE else MDCR_EL3.STE);
        niden = (secure_trace_enable == '0' || ExternalSecureNoninvasiveDebugEnabled());
    else
        // If no EL3, IsSecure() returns the Effective value of (SCR_EL3.NS == '0')
        niden = (!IsSecure() || ExternalSecureNoninvasiveDebugEnabled());
    return (EDSCR.TFO == '0' || !niden);
```

## Library pseudocode for shared/trace/selfhosted/TraceAllowed

```
// TraceAllowed()
// =====
// Returns TRUE if Self-hosted Trace is allowed in the current Security state and Exception level

boolean TraceAllowed()
    if !HaveTraceExt() then return FALSE;
    if SelfHostedTraceEnabled() then
        if IsSecure() && HaveEL(EL3) then
            secure_trace_enable = (if ELUsingAArch32(EL3) then SDCR.STE else MDCR_EL3.STE);
            if secure_trace_enable == '0' then return FALSE;
        TGE_bit = if EL2Enabled() then HCR_EL2.TGE else '0';
        case PSTATE.EL of
            when EL3 TRE_bit = if HighestELUsingAArch32() then TRFCR.E1TRE else '0';
            when EL2 TRE_bit = TRFCR_EL2.E2TRE;
            when EL1 TRE_bit = TRFCR_EL1.E1TRE;
            when EL0 TRE_bit = if TGE_bit == '1' then TRFCR_EL2.E0HTRE else TRFCR_EL1.E0TRE;
        return TRE_bit == '1';
    else
        return (!IsSecure() || ExternalSecureNoninvasiveDebugEnabled());
```

## Library pseudocode for shared/trace/selfhosted/TraceContextIDR2

```
// TraceContextIDR2()
// =====

boolean TraceContextIDR2()
    if !TraceAllowed() || !HaveEL(EL2) then return FALSE;
    return (!SelfHostedTraceEnabled() || TRFCR_EL2.CX == '1');
```

## Library pseudocode for shared/trace/selfhosted/TraceSynchronizationBarrier

```
// Memory barrier instruction that preserves the relative order of memory accesses to System
// registers due to trace operations and other memory accesses to the same registers
TraceSynchronizationBarrier();
```

## Library pseudocode for shared/trace/selfhosted/TraceTimeStamp

```
// TraceTimeStamp()
// =====

TimeStamp TraceTimeStamp()
  if SelfHostedTraceEnabled() then
    if HaveEL(EL2) then
      TS_el2 = TRFCR_EL2.TS;
      if !HaveECVExt() && TS_el2 == '10' then
        // Reserved value
        (-, TS_el2) = ConstrainUnpredictableBits(Unpredictable_EL2TIMESTAMP);

      case TS_el2 of
        when '00'
          // Falls out to check TRFCR_EL1.TS
        when '01'
          return TimeStamp_Virtual;
        when '10'
          assert HaveECVExt(); // Otherwise ConstrainUnpredictableBits removes this case
          return TimeStamp_OffsetPhysical;
        when '11'
          return TimeStamp_Physical;

      TS_el1 = TRFCR_EL1.TS;
      if TS_el1 == '00' || (!HaveECVExt() && TS_el1 == '10') then
        // Reserved value
        (-, TS_el1) = ConstrainUnpredictableBits(Unpredictable_EL1TIMESTAMP);

      case TS_el1 of
        when '01'
          return TimeStamp_Virtual;
        when '10'
          assert HaveECVExt();
          return TimeStamp_OffsetPhysical;
        when '11'
          return TimeStamp_Physical;
        otherwise
          Unreachable(); // ConstrainUnpredictableBits removes this case
    else
      return TimeStamp_CoreSight;
```

## Library pseudocode for shared/translation/attrs/DecodeDevice

```
// DecodeDevice()
// =====
// Decode output Device type

DeviceType DecodeDevice(bits(2) device)
  case device of
    when '00' return DeviceType_nGnRnE;
    when '01' return DeviceType_nGnRE;
    when '10' return DeviceType_nGRE;
    when '11' return DeviceType_GRE;
```



## Library pseudocode for shared/translation/attrs/DecodeLDFAttr

```
// DecodeLDFAttr()
// =====
// Decode memory attributes using LDF (Long Descriptor Format) mapping

MemAttrHints DecodeLDFAttr(bits(4) attr)
    MemAttrHints ldfattr;

    if attr == 'x0xx' then ldfattr.attrs = MemAttr_WT; // Write-through
    elsif attr == '0100' then ldfattr.attrs = MemAttr_NC; // Non-cacheable
    elsif attr == 'x1xx' then ldfattr.attrs = MemAttr_WB; // Write-back
    else
        Unreachable();

    // Allocation hints are applicable only to cacheable memory.
    if ldfattr.attrs != MemAttr_NC then
        case attr<1:0> of
            when '00' ldfattr.hints = MemHint_No; // No allocation hints
            when '01' ldfattr.hints = MemHint_WA; // Write-allocate
            when '10' ldfattr.hints = MemHint_RA; // Read-allocate
            when '11' ldfattr.hints = MemHint_RWA; // Read/Write allocate

    // The Transient hint applies only to cacheable memory with some allocation hints.
    if ldfattr.attrs != MemAttr_NC && ldfattr.hints != MemHint_No then
        ldfattr.transient = attr<3> == '0';

    return ldfattr;
```

## Library pseudocode for shared/translation/attrs/DecodeSDFAttr

```
// DecodeSDFAttr()
// =====
// Decode memory attributes using SDF (Short Descriptor Format) mapping

MemAttrHints DecodeSDFAttr(bits(2) rgn)
    MemAttrHints sdfattr;

    case rgn of
        when '00' // Non-cacheable (no allocate)
            sdfattr.attrs = MemAttr_NC;
        when '01' // Write-back, Read and Write allocate
            sdfattr.attrs = MemAttr_WB;
            sdfattr.hints = MemHint_RWA;
        when '10' // Write-through, Read allocate
            sdfattr.attrs = MemAttr_WT;
            sdfattr.hints = MemHint_RA;
        when '11' // Write-back, Read allocate
            sdfattr.attrs = MemAttr_WB;
            sdfattr.hints = MemHint_RA;

    sdfattr.transient = FALSE;

    return sdfattr;
```

## Library pseudocode for shared/translation/attrs/DecodeShareability

```
// DecodeShareability()
// =====
// Decode shareability of target memory region

Shareability DecodeShareability(bits(2) sh)
    case sh of
        when '10' return Shareability\_OSH;
        when '11' return Shareability\_ISH;
        when '00' return Shareability\_NSH;
        otherwise
            case ConstrainUnpredictable\(Unpredictable\_Shareability\) of
                when Constraint\_OSH return Shareability\_OSH;
                when Constraint\_ISH return Shareability\_ISH;
                when Constraint\_NSH return Shareability\_NSH;
```

## Library pseudocode for shared/translation/attrs/MAIRAttr

```
// MAIRAttr()
// =====
// Retrieve the memory attribute encoding indexed in the given MAIR

bits(8) MAIRAttr(integer index, MAIRType mair)
    bit_index = 8 * index;
    return mair<bit_index+7:bit_index>;
```

## Library pseudocode for shared/translation/attrs/NormalNCMemAttr

```
// NormalNCMemAttr()
// =====
// Normal Non-cacheable memory attributes

MemoryAttributes NormalNCMemAttr()
    MemAttrHints non_cacheable;
    non_cacheable.attrs = MemAttr\_NC;

    MemoryAttributes nc_memattrs;
    nc_memattrs.memtype      = MemType\_Normal;
    nc_memattrs.outer        = non_cacheable;
    nc_memattrs.inner        = non_cacheable;
    nc_memattrs.shareability = Shareability\_OSH;
    nc_memattrs.tagged        = FALSE;

    return nc_memattrs;
```

## Library pseudocode for shared/translation/attrs/S1ConstrainUnpredictableRESMAIR

```
// S1ConstrainUnpredictableRESMAIR()
// =====
// Determine whether a reserved value occupies MAIR_ELx.AttrN

boolean S1ConstrainUnpredictableRESMAIR(bits(8) attr, boolean slaarch64)
    case attr of
        when '0000xx01' return !(slaarch64 && HaveFeatXS());
        when '0000xxxx' return attr<1:0> != '00';
        when '01000000' return !(slaarch64 && HaveFeatXS());
        when '10100000' return !(slaarch64 && HaveFeatXS());
        when '11110000' return !(slaarch64 && HaveMTE2Ext());
        when 'xxxx0000' return TRUE;
        otherwise        return FALSE;
```

## Library pseudocode for shared/translation/attrs/S1DecodeMemAttrs

```
// S1DecodeMemAttrs()
// =====
// Decode MAIR-format memory attributes assigned in stage 1

MemoryAttributes S1DecodeMemAttrs(bits(8) attr, bits(2) sh, boolean slaarch64)
  if S1ConstrainUnpredictableRESMAIR(attr, slaarch64) then
    (-, attr) = ConstrainUnpredictableBits(Unpredictable_RESMAIR);

  MemoryAttributes memattrs;
  case attr of
    when '0000xxxx' // Device memory
      memattrs.memtype      = MemType\_Device;
      memattrs.device       = DecodeDevice(attr<3:2>);
      memattrs.shareability = DecodeShareability(sh);
      memattrs.tagged       = FALSE;
      memattrs.xs           = if slaarch64 then NOT attr<0> else '1';
    when '01000000'
      assert slaarch64 && HaveFeatXS();
      memattrs.memtype      = MemType\_Normal;
      memattrs.tagged       = FALSE;
      memattrs.outer.attrs  = MemAttr\_NC;
      memattrs.inner.attrs  = MemAttr\_NC;
      memattrs.shareability = DecodeShareability(sh);
      memattrs.xs           = '0';

    when '10100000'
      assert slaarch64 && HaveFeatXS();
      memattrs.memtype      = MemType\_Normal;
      memattrs.tagged       = FALSE;
      memattrs.shareability = DecodeShareability(sh);
      memattrs.outer.attrs  = MemAttr\_WT;
      memattrs.outer.hints  = MemHint\_RA;
      memattrs.outer.transient = FALSE;
      memattrs.inner.attrs  = MemAttr\_WT;
      memattrs.inner.hints  = MemHint\_RA;
      memattrs.inner.transient = FALSE;
      memattrs.xs           = '0';
    when '11110000' // Tagged memory
      assert slaarch64 && HaveMTE2Ext();
      memattrs.memtype      = MemType\_Normal;
      memattrs.tagged       = TRUE;
      memattrs.shareability = DecodeShareability(sh);
      memattrs.outer.attrs  = MemAttr\_WB;
      memattrs.outer.hints  = MemHint\_RWA;
      memattrs.outer.transient = FALSE;
      memattrs.inner.attrs  = MemAttr\_WB;
      memattrs.inner.hints  = MemHint\_RWA;
      memattrs.inner.transient = FALSE;
      memattrs.xs           = '0';
    otherwise
      memattrs.memtype      = MemType\_Normal;
      memattrs.outer        = DecodeLDFAttr(attr<7:4>);
      memattrs.inner        = DecodeLDFAttr(attr<3:0>);
      memattrs.shareability = DecodeShareability(sh);
      memattrs.tagged       = FALSE;

      if (memattrs.inner.attrs == MemAttr\_WB &&
          memattrs.outer.attrs == MemAttr\_WB) then
        memattrs.xs = '0';
      else
        memattrs.xs = '1';

  return memattrs;
```

## Library pseudocode for shared/translation/attrs/S2CombineS1AttrHints

```
// S2CombineS1AttrHints()
// =====
// Determine resultant Normal memory cacheability and allocation hints from
// combining stage 1 Normal memory attributes and stage 2 cacheability attributes.

MemAttrHints S2CombineS1AttrHints(MemAttrHints s1_attrhints, MemAttrHints s2_attrhints)
    MemAttrHints attrhints;

    if s1_attrhints.attrs == MemAttr_NC || s2_attrhints.attrs == MemAttr_NC then
        attrhints.attrs = MemAttr_NC;
    elsif s1_attrhints.attrs == MemAttr_WT || s2_attrhints.attrs == MemAttr_WT then
        attrhints.attrs = MemAttr_WT;
    else
        attrhints.attrs = MemAttr_WB;

    // Stage 2 does not assign any allocation hints
    // Instead, they are inherited from stage 1
    if attrhints.attrs != MemAttr_NC then
        attrhints.hints      = s1_attrhints.hints;
        attrhints.transient = s1_attrhints.transient;

    return attrhints;
```

## Library pseudocode for shared/translation/attrs/S2CombineS1Device

```
// S2CombineS1Device()
// =====
// Determine resultant Device type from combining output memory attributes
// in stage 1 and Device attributes in stage 2

DeviceType S2CombineS1Device(DeviceType s1_device, DeviceType s2_device)
    if s1_device == DeviceType_nGnRnE || s2_device == DeviceType_nGnRnE then
        return DeviceType_nGnRnE;
    elsif s1_device == DeviceType_nGnRE || s2_device == DeviceType_nGnRE then
        return DeviceType_nGnRE;
    elsif s1_device == DeviceType_nGRE || s2_device == DeviceType_nGRE then
        return DeviceType_nGRE;
    else
        return DeviceType_GRE;
```

## Library pseudocode for shared/translation/attrs/S2CombineS1MemAttrs

```
// S2CombineS1MemAttrs()
// =====
// Combine stage 2 with stage 1 memory attributes

MemoryAttributes S2CombineS1MemAttrs(MemoryAttributes s1_memattrs,
                                     MemoryAttributes s2_memattrs)
    MemoryAttributes memattrs;

    if s1_memattrs.memtype == MemType_Device && s2_memattrs.memtype == MemType_Device then
        memattrs.memtype      = MemType_Device;
        memattrs.device       = S2CombineS1Device(s1_memattrs.device, s2_memattrs.device);
        memattrs.shareability = Shareability_OSH;
    elsif s1_memattrs.memtype == MemType_Device then // S2 Normal, S1 Device
        memattrs = s1_memattrs;
        memattrs.shareability = Shareability_OSH;
    elsif s2_memattrs.memtype == MemType_Device then // S2 Device, S1 Normal
        memattrs = s2_memattrs;
        memattrs.shareability = Shareability_OSH;
    else // S2 Normal, S1 Normal
        memattrs.memtype = MemType_Normal;
        memattrs.inner   = S2CombineS1AttrHints(s1_memattrs.inner, s2_memattrs.inner);
        memattrs.outer   = S2CombineS1AttrHints(s1_memattrs.outer, s2_memattrs.outer);

        if memattrs.inner.attrs == MemAttr_NC && memattrs.outer.attrs == MemAttr_NC then
            memattrs.shareability = Shareability_OSH;
        else
            memattrs.shareability = S2CombineS1Shareability(s1_memattrs.shareability,
                                                            s2_memattrs.shareability);

    if ELUsingAArch32(EL2) || !HaveMTE2Ext() then
        memattrs.tagged = FALSE;
    else
        memattrs.tagged = AArch64.IsS2ResultTagged(memattrs, s1_memattrs.tagged);

    memattrs.xs = s2_memattrs.xs;

    return memattrs;
```

## Library pseudocode for shared/translation/attrs/S2CombineS1Shareability

```
// S2CombineS1Shareability()
// =====
// Combine stage 2 shareability with stage 1

Shareability S2CombineS1Shareability(Shareability s1_shareability,
                                     Shareability s2_shareability)

    if (s1_shareability == Shareability_OSH ||
        s2_shareability == Shareability_OSH) then
        return Shareability_OSH;
    elsif (s1_shareability == Shareability_ISH ||
          s2_shareability == Shareability_ISH) then
        return Shareability_ISH;
    else
        return Shareability_NSH;
```

## Library pseudocode for shared/translation/attrs/S2DecodeCacheability

```
// S2DecodeCacheability()
// =====
// Determine the stage 2 cacheability for Normal memory

MemAttrHints S2DecodeCacheability(bits(2) attr)
  MemAttrHints s2attr;

  case attr of
    when '01' s2attr.attrs = MemAttr_NC; // Non-cacheable
    when '10' s2attr.attrs = MemAttr_WT; // Write-through
    when '11' s2attr.attrs = MemAttr_WB; // Write-back
    otherwise // Constrained unpredictable
      case ConstrainUnpredictable(Unpredictable_S2RESMEMATTR) of
        when Constraint_NC s2attr.attrs = MemAttr_NC;
        when Constraint_WT s2attr.attrs = MemAttr_WT;
        when Constraint_WB s2attr.attrs = MemAttr_WB;

  // Stage 2 does not assign hints or the transient property
  // They are inherited from stage 1 if the result of the combination allows it
  s2attr.hints = bits(2) UNKNOWN;
  s2attr.transient = boolean UNKNOWN;

  return s2attr;
```

## Library pseudocode for shared/translation/attrs/S2DecodeMemAttrs

```
// S2DecodeMemAttrs()
// =====
// Decode stage 2 memory attributes

MemoryAttributes S2DecodeMemAttrs(bits(4) attr, bits(2) sh)
  MemoryAttributes memattrs;

  case attr of
    when '00xx' // Device memory
      memattrs.memtype = MemType_Device;
      memattrs.device = DecodeDevice(attr<1:0>);
      memattrs.shareability = Shareability_OSH;
    otherwise // Normal memory
      memattrs.memtype = MemType_Normal;
      memattrs.outer = S2DecodeCacheability(attr<3:2>);
      memattrs.inner = S2DecodeCacheability(attr<1:0>);

      if (memattrs.inner.attrs == MemAttr_NC &&
          memattrs.outer.attrs == MemAttr_NC) then
        memattrs.shareability = Shareability_OSH;
      else
        memattrs.shareability = DecodeShareability(sh);

  return memattrs;
```

## Library pseudocode for shared/translation/attrs/WalkMemAttrs

```
// WalkMemAttrs()
// =====
// Retrieve memory attributes of translation table walk

MemoryAttributes WalkMemAttrs(bits(2) sh, bits(2) irgn, bits(2) orgn)
    MemoryAttributes walkmemattrs;

    walkmemattrs.memtype      = MemType_Normal;
    walkmemattrs.shareability = DecodeShareability(sh);
    walkmemattrs.inner       = DecodeSDFAttr(irgn);
    walkmemattrs.outer       = DecodeSDFAttr(orn);
    walkmemattrs.tagged      = FALSE;
    if (walkmemattrs.inner.attrs == MemAttr_WB &&
        walkmemattrs.outer.attrs == MemAttr_WB) then
        walkmemattrs.xs = '0';
    else
        walkmemattrs.xs = '1';

    return walkmemattrs;
```

## Library pseudocode for shared/translation/faults/AlignmentFault

```
// AlignmentFault()
// =====

FaultRecord AlignmentFault(AccType acctype, boolean iswrite, boolean secondstage)
    FaultRecord fault;

    fault.statuscode = Fault_Alignment;
    fault.acctype    = acctype;
    fault.write      = iswrite;
    fault.secondstage = secondstage;

    return fault;
```

## Library pseudocode for shared/translation/faults/AsyncExternalAbort

```
// AsyncExternalAbort()
// =====
// Return a fault record indicating an asynchronous external abort

FaultRecord AsyncExternalAbort(boolean parity, bits(2) errortype, bit extflag)
    FaultRecord fault;

    fault.statuscode = if parity then Fault_AsyncParity else Fault_AsyncExternal;
    fault.extflag    = extflag;
    fault.errortype   = errortype;
    fault.acctype     = AccType_NORMAL;
    fault.secondstage = FALSE;
    fault.s2fslwalk  = FALSE;

    return fault;
```

## Library pseudocode for shared/translation/faults/NoFault

```
// NoFault()
// =====
// Return a clear fault record indicating no faults have occurred

FaultRecord NoFault()
    FaultRecord fault;

    fault.statuscode = Fault\_None;
    fault.acctype = AccType\_NORMAL;
    fault.secondstage = FALSE;
    fault.s2fslwalk = FALSE;

    return fault;
```

## Library pseudocode for shared/translation/translation/HasS2Translation

```
// HasS2Translation()
// =====
// Returns TRUE if stage 2 translation is present for the current translation regime

boolean HasS2Translation()
    return (EL2Enabled() && !IsInHost() && PSTATE.EL IN {EL0,EL1});
```

## Library pseudocode for shared/translation/translation/Have16bitVMID

```
// Have16bitVMID()
// =====
// Returns TRUE if EL2 and support for a 16-bit VMID are implemented.

boolean Have16bitVMID()
    return HaveEL(EL2) && boolean IMPLEMENTATION_DEFINED "Has 16-bit VMID";
```

## Library pseudocode for shared/translation/translation/S1TranslationRegime

```
// S1TranslationRegime()
// =====
// Stage 1 translation regime for the given Exception level

bits(2) S1TranslationRegime(bits(2) el)
    if el != EL0 then
        return el;
    elsif HaveEL(EL3) && ELUsingAArch32(EL3) && SCR.NS == '0' then
        return EL3;
    elsif HaveVirtHostExt() && ELIsInHost(el) then
        return EL2;
    else
        return EL1;

// S1TranslationRegime()
// =====
// Returns the Exception level controlling the current Stage 1 translation regime. For the most
// part this is unused in code because the system register accessors (SCTLR[], etc.) implicitly
// return the correct value.

bits(2) S1TranslationRegime()
    return S1TranslationRegime(PSTATE.EL);
```



## Library pseudocode for shared/translation/vmsa/CreateAddressDescriptor

```
// CreateAddressDescriptor()
// =====
// Set internal members for address descriptor type to valid values

AddressDescriptor CreateAddressDescriptor(bits(64) va, FullAddress pa,
                                         MemoryAttributes memattrs)

    AddressDescriptor addrdesc;

    addrdesc.paddress = pa;
    addrdesc.vaddress = va;
    addrdesc.memattrs = memattrs;
    addrdesc.fault    = NoFault();

    return addrdesc;
```

## Library pseudocode for shared/translation/vmsa/CreateFaultyAddressDescriptor

```
// CreateFaultyAddressDescriptor()
// =====
// Set internal members for address descriptor type with values indicating error

AddressDescriptor CreateFaultyAddressDescriptor(bits(64) va, FaultRecord fault)
    AddressDescriptor addrdesc;

    addrdesc.vaddress = va;
    addrdesc.fault    = fault;

    return addrdesc;
```

## Library pseudocode for shared/translation/vmsa/DescriptorType

```
enumeration DescriptorType {
    DescriptorType_Table,
    DescriptorType_Block,
    DescriptorType_Page,
    DescriptorType_Invalid
};
```

## Library pseudocode for shared/translation/vmsa/Domains

```
constant bits(2) Domain_NoAccess = '00';
constant bits(2) Domain_Client   = '01';
constant bits(2) Domain_Manager  = '11';
```

## Library pseudocode for shared/translation/vmsa/FetchDescriptor

```
// FetchDescriptor()
// =====
// Fetch a translation table descriptor

(FaultRecord, bits(N)) FetchDescriptor(bit ee, AddressDescriptor walkaddress,
                                       FaultRecord fault)
    // 32-bit descriptors for AArch32 Short-descriptor format
    // 64-bit descriptors for AArch64 or AArch32 Long-descriptor format
    assert N == 32 || N == 64;
    bits(N) descriptor;

    // These parameters are for the Abort() call on the other side of _Mem
    walkacc = CreateAccessDescriptorTTW(fault.acctype, fault.secondstage,
                                       fault.s2fslwalk, fault.level);

    descriptor = _Mem[walkaddress, N DIV 8, walkacc, fault.write];

    if ee == '1' then
        descriptor = BigEndianReverse(descriptor);

    return (fault, descriptor);
```

## Library pseudocode for shared/translation/vmsa/HasUnprivileged

```
// HasUnprivileged()
// =====
// Returns whether a translation regime serves EL0 as well as a higher EL

boolean HasUnprivileged(Regime regime)
    return (regime IN {
        Regime_EL20,
        Regime_EL30,
        Regime_EL10
    });
```

## Library pseudocode for shared/translation/vmsa/IsAtomicRW

```
// IsAtomicRW()
// =====
// Is the access an atomic operation?

boolean IsAtomicRW(AccType acctype)
    return acctype IN {
        AccType_ATOMICRW,
        AccType_ORDEREDRW,
        AccType_ORDEREDATOMICRW
    };
```

## Library pseudocode for shared/translation/vmsa/Regime

```
enumeration Regime {
    Regime_EL3,           // EL3
    Regime_EL30,          // EL3&0 (PL1&0 when EL3 is AArch32)
    Regime_EL2,           // EL2
    Regime_EL20,          // EL2&0
    Regime_EL10           // EL1&0
};
```

## Library pseudocode for shared/translation/vmsa/RegimeUsingAArch32

```
// RegimeUsingAArch32()
// =====
// Determine if the EL controlling the regime executes in AArch32 state

boolean RegimeUsingAArch32(Regime regime)
    case regime of
        when Regime_EL10 return ELUsingAArch32(EL1);
        when Regime_EL30 return TRUE;
        when Regime_EL20 return FALSE;
        when Regime_EL2 return ELUsingAArch32(EL2);
        when Regime_EL3 return FALSE;
```

## Library pseudocode for shared/translation/vmsa/S1TTWParams

```
type S1TTWParams is (
// A64-VMSA exclusive parameters
    bit      ha,          // TCR_ELx.HA
    bit      hd,          // TCR_ELx.HD
    bit      tbi,         // TCR_ELx.TBI{x}
    bit      tbiid,        // TCR_ELx.TBID{x}
    bit      nfd,          // TCR_EL1.NFDx or TCR_EL2.NFDx when HCR_EL2.E2H == '1'
    bit      e0pd,         // TCR_EL1.E0PDx or TCR_EL2.E0PDx when HCR_EL2.E2H == '1'
    bit      ds,           // TCR_ELx.DS
    bits(3)   ps,          // TCR_ELx.{I}PS
    bits(6)   txsz,        // TCR_ELx.TxSZ
    bit      epan,         // SCTLR_EL1.EPAN or SCTLR_EL2.EPAN when HCR_EL2.E2H == '1'
    bit      dct,          // HCR_EL2.DCT
    bit      nv1,          // HCR_EL2.NV1

// A32-VMSA exclusive parameters
    bits(3)   t0sz,        // TTBCR.T0SZ
    bits(3)   t1sz,        // TTBCR.T1SZ
    bit      uwxn,         // SCTLR.UWXN

// Parameters common to both A64-VMSA & A32-VMSA (A64/A32)
    TGx      tgx,          // TCR_ELx.TGx      / Always TGx_4KB
    bits(2)   irgn,         // TCR_ELx.IRGNx    / TTBCR.IRGNx or HTCR.IRGN0
    bits(2)   orgn,         // TCR_ELx.ORGNx    / TTBCR.ORGnx or HTCR.ORGNO
    bits(2)   sh,           // TCR_ELx.SHx      / TTBCR.SHx or HTCR.SH0
    bit      hpd,           // TCR_ELx.HPD{x}   / TTBCR2.HPDx or HTCR.HPD
    bit      ee,            // SCTLR_ELx.EE      / SCTLR.EE or HSCTLR.EE
    bit      wxn,           // SCTLR_ELx.WXN     / SCTLR.WXN or HSCTLR.WXN
    bit      ntlsmd,        // SCTLR_ELx.nTLSMD / SCTLR.nTLSMD or HSCTLR.nTLSMD
    bit      dc,            // HCR_EL2.DC        / HCR.DC
    bit      sif,           // SCR_EL3.SIF       / SCR.SIF
    MAIRType mair          // MAIR_ELx          / MAIR1:MAIR0 or HMAIR1:HMAIR0
)
```

## Library pseudocode for shared/translation/vmsa/S2TTWParams

```
type S2TTWParams is (  
  // A64-VMSA exclusive parameters  
  bit      ha,      // VTCR_EL2.HA  
  bit      hd,      // VTCR_EL2.HD  
  bit      sl2,     // V{S}TCR_EL2.SL2  
  bit      ds,      // VTCR_EL2.DS  
  bit      sw,      // VSTCR_EL2.SW  
  bit      nsw,     // VTCR_EL2.NSW  
  bit      sa,      // VSTCR_EL2.SA  
  bit      nsa,     // VTCR_EL2.NSA  
  bits(3)  ps,      // VTCR_EL2.PS  
  bits(6)  txsz,    // V{S}TCR_EL2.T0SZ  
  bit      fwb,     // HCR_EL2.PTW  
  
  // A32-VMSA exclusive parameters  
  bit      s,       // VTCR.S  
  bits(4)  t0sz,    // VTCR.T0SZ  
  
  // Parameters common to both A64-VMSA & A32-VMSA if implemented (A64/A32)  
  TGx      tgx,     // V{S}TCR_EL2.TG0 / Always TGx_4KB  
  bits(2)  sl0,     // V{S}TCR_EL2.SL0 / VTCR.SL0  
  bits(2)  irgn,    // VTCR_EL2.IRGN0 / VTCR.IRGN0  
  bits(2)  orgn,    // VTCR_EL2.ORGNO / VTCR.ORGNO  
  bits(2)  sh,      // VTCR_EL2.SH0 / VTCR.SH0  
  bit      ee,      // SCTLR_EL2.EE / HSCTLR.EE  
  bit      ptw,     // HCR_EL2.PTW / HCR.PTW  
  bit      vm,      // HCR_EL2.VM / HCR.VM  
)  
  
constant integer FINAL_LEVEL = 3;
```

## Library pseudocode for shared/translation/vmsa/SDFTType

```
enumeration SDFTType {  
  SDFTType_Table,  
  SDFTType_Invalid,  
  SDFTType_Supersection,  
  SDFTType_Section,  
  SDFTType_LargePage,  
  SDFTType_SmallPage  
};
```

## Library pseudocode for shared/translation/vmsa/SecurityStateForRegime

```
// SecurityStateForRegime()  
// =====  
// Return the Security State of the given translation regime  
  
SecurityState SecurityStateForRegime(Regime regime)  
  case regime of  
    when Regime_EL3      return SecurityStateAtEL(EL3);  
    when Regime_EL30     return SS_Secure; // A32 EL3 is always Secure  
    when Regime_EL2      return SecurityStateAtEL(EL2);  
    when Regime_EL20     return SecurityStateAtEL(EL2);  
    when Regime_EL10     return SecurityStateAtEL(EL1);
```

## Library pseudocode for shared/translation/vmsa/StageOA

```
// StageOA()
// =====
// Given the final walk state (a page or block descriptor), map the untranslated
// input address bits to the output address

FullAddress StageOA(FullAddress outputbase, bits(64) ia, TGx tgx, integer level)
    // Output Address
    FullAddress oa;

    tsize = TranslationSize(tgx, level);

    oa.paspace = outputbase.paspace;
    oa.address = outputbase.address<51:tsize>:ia<tsize-1:0>;

    return oa;
```

## Library pseudocode for shared/translation/vmsa/TGx

```
enumeration TGx {
    TGx_4KB,
    TGx_16KB,
    TGx_64KB
};
```

## Library pseudocode for shared/translation/vmsa/TGxGranuleBits

```
// TGxGranuleBits()
// =====
// Retrieve the address size, in bits, of a granule

integer TGxGranuleBits(TGx tgx)
    case tgx of
        when TGx\_4KB return 12;
        when TGx\_16KB return 14;
        when TGx\_64KB return 16;
```

## Library pseudocode for shared/translation/vmsa/TTWState

```
type TTWState is (
    boolean          istable,
    integer          level,
    FullAddress      baseaddress,
    bit              contiguous,
    bit              guardedpage,
    SDFTType         sdftype, // AArch32 Short-descriptor format walk only
    bits(4)          domain, // AArch32 Short-descriptor format walk only
    MemoryAttributes memattrs,
    Permissions      permissions
)
```

## Library pseudocode for shared/translation/vmsa/TranslationRegime

```
// TranslationRegime()
// =====
// Select the translation regime given the target EL and PE state

Regime TranslationRegime(bits(2) el, AccType acctype)
    if el == EL3 then
        return if ELUsingAArch32(EL3) then Regime_EL30 else Regime_EL3;
    elsif el == EL2 then
        return if ELIsInHost(EL2) then Regime_EL20 else Regime_EL2;
    elsif el == EL1 then
        if acctype == AccType_NV2REGISTER then
            assert EL2Enabled();
            return if ELIsInHost(EL2) then Regime_EL20 else Regime_EL2;
        else
            return Regime_EL10;
    elsif el == EL0 then
        if IsSecure() && ELUsingAArch32(EL3) then
            return Regime_EL30;
        elsif ELIsInHost(EL0) then
            return Regime_EL20;
        else
            return Regime_EL10;
    else
        Unreachable();
```

## Library pseudocode for shared/translation/vmsa/TranslationSize

```
// TranslationSize()
// =====
// Compute the number of bits directly mapped from the input address
// to the output address

integer TranslationSize(TGx tgx, integer level)
    granulebits = TGxGranuleBits(tgx);
    blockbits   = (FINAL_LEVEL - level) * (granulebits - 3);

    return granulebits + blockbits;
```

## Library pseudocode for shared/translation/vmsa/VARange

```
enumeration VARange {
    VARange_LOWER,
    VARange_UPPER
};
```

Internal version only: isa v32.15, AdvSIMD v29.05, pseudocode v2021-03, sve v2021-03\_rc2 ; Build timestamp: 2021-03-30T22:41

Copyright © 2010-2021 Arm Limited or its affiliates. All rights reserved. This document is Non-Confidential.