

# ARM® and Thumb®-2 Instruction Set

## Quick Reference Card

| Key to Tables |  |              |   |
|---------------|--|--------------|---|
| Rm {, <opsh>} | See Table <b>Register, optionally shifted by constant</b>  | <reglist>    | A comma-separated list of registers, enclosed in braces { and }.            |
| <Operand2>    | See Table <b>Flexible Operand 2</b> . Shift and rotate are only available as part of Operand2.   | <reglist-PC> | As <reglist>, must not include the PC.                                      |
| <fields>      | See Table <b>PSR fields</b> .  | <reglist+PC> | As <reglist>, including the PC.   |
| <PSR>         | APSR (Application Program Status Register), CPSR (Current Processor Status Register), or SPSR (Saved Processor Status Register)  | <flags>      | Either nzcvq (ALU flags PSR[31:27]) or g (SIMD GE flags PSR[19:16])         |
| C*, V*        | Flag is unpredictable in Architecture v4 and earlier, unchanged in Architecture v5 and later.  | §            | See Table <b>ARM architecture versions</b> .                                |
| <Rs sh>       | Can be Rs or an immediate shift value. The values allowed for each shift type are the same as those shown in Table <b>Register, optionally shifted by constant</b> .   | +/-          | + or -. (+ may be omitted.)   |
| x, y          | B meaning half-register [15:0], or T meaning [31:16].  | <iflags>     | Interrupt flags. One or more of a, i, f (abort, interrupt, fast interrupt). |
| <imm8m>       | ARM: a 32-bit constant, formed by right-rotating an 8-bit value by an even number of bits.<br>Thumb: a 32-bit constant, formed by left-shifting an 8-bit value by any number of bits, or a bit pattern of one of the forms 0xXYXYXYXY, 0x00XY00XY or 0xXY00XY00. | <p_mode>     | See Table <b>Processor Modes</b>  |
| <prefix>      | See Table <b>Prefixes for Parallel instructions</b>  | SPm          | SP for the processor mode specified by <p_mode>                             |
| {IA IB DA DB} | Increment After, Increment Before, Decrement After, or Decrement Before.<br>IB and DA are not available in Thumb state. If omitted, defaults to IA.  | <lsb>        | Least significant bit of bitfield.  |
| <size>        | B, SB, H, or SH, meaning Byte, Signed Byte, Halfword, and Signed Halfword respectively.<br>SB and SH are not available in STR instructions.  | <width>      | Width of bitfield. <width> + <lsb> must be <= 32.                           |
|               |  | {X}          | RsX is Rs rotated 16 bits if X present. Otherwise, RsX is Rs.               |
|               |  | {!}          | Updates base register after data transfer if ! present (pre-indexed).       |
|               |  | {S}          | Updates condition flags if S present.                                       |
|               |  | {T}          | User mode privilege if T present.   |
|               |  | {R}          | Rounds result to nearest if R present, otherwise truncates result.          |

| Operation                  | §                                     | Assembler                         | S updates | Action   | Notes |
|----------------------------|---------------------------------------|-----------------------------------|-----------|--|-------|
| <b>Add</b>                 | Add                                   | ADD{S} Rd, Rn, <Operand2>         | N Z C V   | Rd := Rn + Operand2  | N     |
|                            | with carry                            | ADC{S} Rd, Rn, <Operand2>         | N Z C V   | Rd := Rn + Operand2 + Carry  | N     |
|                            | wide                                  | ADD Rd, Rn, #<imm12>              |           | Rd := Rn + imm12, imm12 range 0-4095   | T, P  |
|                            | saturating {doubled}                  | Q{D}ADD Rd, Rm, Rn                |           | Rd := SAT(Rm + Rn)      doubled: Rd := SAT(Rm + SAT(Rn * 2))   | Q     |
| <b>Address</b>             | Form PC-relative address              | ADR Rd, <label>                   |           | Rd := <label>, for <label> range from current instruction see Note L   | N, L  |
| <b>Subtract</b>            | Subtract                              | SUB{S} Rd, Rn, <Operand2>         | N Z C V   | Rd := Rn - Operand2  | N     |
|                            | with carry                            | SBC{S} Rd, Rn, <Operand2>         | N Z C V   | Rd := Rn - Operand2 - NOT(Carry)   | N     |
|                            | wide                                  | SUB Rd, Rn, #<imm12>              |           | Rd := Rn - imm12, imm12 range 0-4095   | T, P  |
|                            | reverse subtract                      | RSB{S} Rd, Rn, <Operand2>         | N Z C V   | Rd := Operand2 - Rn  | N     |
|                            | reverse subtract with carry           | RSC{S} Rd, Rn, <Operand2>         | N Z C V   | Rd := Operand2 - Rn - NOT(Carry)   | A     |
|                            | saturating {doubled}                  | Q{D}SUB Rd, Rm, Rn                |           | Rd := SAT(Rm - Rn)      doubled: Rd := SAT(Rm - SAT(Rn * 2))   | Q     |
|                            | Exception return without stack        | SUBS PC, LR, #<imm8>              | N Z C V   | PC = LR - imm8, CPSR = SPSR(current mode), imm8 range 0-255.   |       |
| <b>Parallel arithmetic</b> | Halfword-wise addition                | 6 <prefix>ADD16 Rd, Rn, Rm        |           | Rd[31:16] := Rn[31:16] + Rm[31:16], Rd[15:0] := Rn[15:0] + Rm[15:0]  | G     |
|                            | Halfword-wise subtraction             | 6 <prefix>SUB16 Rd, Rn, Rm        |           | Rd[31:16] := Rn[31:16] - Rm[31:16], Rd[15:0] := Rn[15:0] - Rm[15:0]  | G     |
|                            | Byte-wise addition                    | 6 <prefix>ADD8 Rd, Rn, Rm         |           | Rd[31:24] := Rn[31:24] + Rm[31:24], Rd[23:16] := Rn[23:16] + Rm[23:16],<br>Rd[15:8] := Rn[15:8] + Rm[15:8], Rd[7:0] := Rn[7:0] + Rm[7:0] | G     |
|                            | Byte-wise subtraction                 | 6 <prefix>SUB8 Rd, Rn, Rm         |           | Rd[31:24] := Rn[31:24] - Rm[31:24], Rd[23:16] := Rn[23:16] - Rm[23:16],<br>Rd[15:8] := Rn[15:8] - Rm[15:8], Rd[7:0] := Rn[7:0] - Rm[7:0] | G     |
|                            | Halfword-wise exchange, add, subtract | 6 <prefix>ASX Rd, Rn, Rm          |           | Rd[31:16] := Rn[31:16] + Rm[15:0], Rd[15:0] := Rn[15:0] - Rm[31:16]  | G     |
|                            | Halfword-wise exchange, subtract, add | 6 <prefix>SAX Rd, Rn, Rm          |           | Rd[31:16] := Rn[31:16] - Rm[15:0], Rd[15:0] := Rn[15:0] + Rm[31:16]  | G     |
|                            | Unsigned sum of absolute differences  | 6 USAD8 Rd, Rm, Rs                |           | Rd := Abs(Rm[31:24] - Rs[31:24]) + Abs(Rm[23:16] - Rs[23:16])<br>+ Abs(Rm[15:8] - Rs[15:8]) + Abs(Rm[7:0] - Rs[7:0])                     |       |
|                            | and accumulate                        | 6 USADA8 Rd, Rm, Rs, Rn           |           | Rd := Rn + Abs(Rm[31:24] - Rs[31:24]) + Abs(Rm[23:16] - Rs[23:16])<br>+ Abs(Rm[15:8] - Rs[15:8]) + Abs(Rm[7:0] - Rs[7:0])                |       |
| <b>Saturate</b>            | Signed saturate word, right shift     | 6 SSAT Rd, #<sat>, Rm{, ASR <sh>} |           | Rd := SignedSat((Rm ASR sh), sat). <sat> range 1-32, <sh> range 1-31.  | Q, R  |
|                            | Signed saturate word, left shift      | 6 SSAT Rd, #<sat>, Rm{, LSL <sh>} |           | Rd := SignedSat((Rm LSL sh), sat). <sat> range 1-32, <sh> range 0-31.  | Q     |
|                            | Signed saturate two halfwords         | 6 SSAT16 Rd, #<sat>, Rm           |           | Rd[31:16] := SignedSat(Rm[31:16], sat),<br>Rd[15:0] := SignedSat(Rm[15:0], sat). <sat> range 1-16.                                       | Q     |
|                            | Unsigned saturate word, right shift   | 6 USAT Rd, #<sat>, Rm{, ASR <sh>} |           | Rd := UnsignedSat((Rm ASR sh), sat). <sat> range 0-31, <sh> range 1-31.  | Q, R  |
|                            | Unsigned saturate word, left shift    | 6 USAT Rd, #<sat>, Rm{, LSL <sh>} |           | Rd := UnsignedSat((Rm LSL sh), sat). <sat> range 0-31, <sh> range 0-31.  | Q     |
|                            | Unsigned saturate two halfwords       | 6 USAT16 Rd, #<sat>, Rm           |           | Rd[31:16] := UnsignedSat(Rm[31:16], sat),<br>Rd[15:0] := UnsignedSat(Rm[15:0], sat). <sat> range 0-15.                                   | Q     |



# ARM and Thumb-2 Instruction Set

## Quick Reference Card

| Operation                       |  | §                    | Assembler   | Action   | Notes |
|---------------------------------|--|----------------------|---|--|-------|
| <b>Bit field</b>                | Bit Field Clear  | T2                   | BFC Rd, #<lsb>, #<width>  | Rd[(width+lsb-1):lsb] := 0, other bits of Rd unaffected  |       |
|                                 | Bit Field Insert                                       | T2                   | BFI Rd, Rn, #<lsb>, #<width>  | Rd[(width+lsb-1):lsb] := Rn[(width-1):0], other bits of Rd unaffected  |       |
|                                 | Signed Bit Field Extract                               | T2                   | SBFX Rd, Rn, #<lsb>, #<width>   | Rd[(width-1):0] = Rn[(width+lsb-1):lsb], Rd[31:width] = Replicate( Rn[width+lsb-1] )   |       |
|                                 | Unsigned Bit Field Extract                             | T2                   | UBFX Rd, Rn, #<lsb>, #<width>   | Rd[(width-1):0] = Rn[(width+lsb-1):lsb], Rd[31:width] = Replicate( 0 )   |       |
| <b>Pack</b>                     | Pack halfword bottom + top                             | 6                    | PKHBT Rd, Rn, Rm{, LSL #<sh>}   | Rd[15:0] := Rn[15:0], Rd[31:16] := (Rm LSL sh)[31:16]. sh 0-31.  |       |
|                                 | Pack halfword top + bottom                             | 6                    | PKHTB Rd, Rn, Rm{, ASR #<sh>}   | Rd[31:16] := Rn[31:16], Rd[15:0] := (Rm ASR sh)[15:0]. sh 1-32.  |       |
| <b>Signed extend</b>            | Halfword to word                                       | 6                    | SXTH Rd, Rm{, ROR #<sh>}  | Rd[31:0] := SignExtend((Rm ROR (8 * sh))[15:0]). sh 0-3.   | N     |
|                                 | Two bytes to halfwords                                 | 6                    | SXTB16 Rd, Rm{, ROR #<sh>}  | Rd[31:16] := SignExtend((Rm ROR (8 * sh))[23:16]),<br>Rd[15:0] := SignExtend((Rm ROR (8 * sh))[7:0]). sh 0-3.  |       |
|                                 | Byte to word   | 6                    | SXTB Rd, Rm{, ROR #<sh>}  | Rd[31:0] := SignExtend((Rm ROR (8 * sh))[7:0]). sh 0-3.  | N     |
| <b>Unsigned extend</b>          | Halfword to word                                       | 6                    | UXTH Rd, Rm{, ROR #<sh>}  | Rd[31:0] := ZeroExtend((Rm ROR (8 * sh))[15:0]). sh 0-3.   | N     |
|                                 | Two bytes to halfwords                                 | 6                    | UXTB16 Rd, Rm{, ROR #<sh>}  | Rd[31:16] := ZeroExtend((Rm ROR (8 * sh))[23:16]),<br>Rd[15:0] := ZeroExtend((Rm ROR (8 * sh))[7:0]). sh 0-3.  |       |
|                                 | Byte to word   | 6                    | UXTB Rd, Rm{, ROR #<sh>}  | Rd[31:0] := ZeroExtend((Rm ROR (8 * sh))[7:0]). sh 0-3.  | N     |
| <b>Signed extend with add</b>   | Halfword to word, add                                  | 6                    | SXTAH Rd, Rn, Rm{, ROR #<sh>}   | Rd[31:0] := Rn[31:0] + SignExtend((Rm ROR (8 * sh))[15:0]). sh 0-3.  |       |
|                                 | Two bytes to halfwords, add                            | 6                    | SXTAB16 Rd, Rn, Rm{, ROR #<sh>}   | Rd[31:16] := Rn[31:16] + SignExtend((Rm ROR (8 * sh))[23:16]),<br>Rd[15:0] := Rn[15:0] + SignExtend((Rm ROR (8 * sh))[7:0]). sh 0-3.   |       |
|                                 | Byte to word, add                                      | 6                    | SXTAB Rd, Rn, Rm{, ROR #<sh>}   | Rd[31:0] := Rn[31:0] + SignExtend((Rm ROR (8 * sh))[7:0]). sh 0-3.   |       |
| <b>Unsigned extend with add</b> | Halfword to word, add                                  | 6                    | UXTAH Rd, Rn, Rm{, ROR #<sh>}   | Rd[31:0] := Rn[31:0] + ZeroExtend((Rm ROR (8 * sh))[15:0]). sh 0-3.  |       |
|                                 | Two bytes to halfwords, add                            | 6                    | UXTAB16 Rd, Rn, Rm{, ROR #<sh>}   | Rd[31:16] := Rn[31:16] + ZeroExtend((Rm ROR (8 * sh))[23:16]),<br>Rd[15:0] := Rn[15:0] + ZeroExtend((Rm ROR (8 * sh))[7:0]). sh 0-3.   |       |
|                                 | Byte to word, add                                      | 6                    | UXTAB Rd, Rn, Rm{, ROR #<sh>}   | Rd[31:0] := Rn[31:0] + ZeroExtend((Rm ROR (8 * sh))[7:0]). sh 0-3.   |       |
| <b>Reverse</b>                  | Bits in word   | T2                   | RBIT Rd, Rm   | For (i = 0; i < 32; i++) : Rd[i] = Rm[31 - i]  |       |
|                                 | Bytes in word  | 6                    | REV Rd, Rm  | Rd[31:24] := Rm[7:0], Rd[23:16] := Rm[15:8], Rd[15:8] := Rm[23:16], Rd[7:0] := Rm[31:24]   | N     |
|                                 | Bytes in both halfwords                                | 6                    | REV16 Rd, Rm  | Rd[15:8] := Rm[7:0], Rd[7:0] := Rm[15:8], Rd[31:24] := Rm[23:16], Rd[23:16] := Rm[31:24]   | N     |
|                                 | Bytes in low halfword, sign extend                     | 6                    | REVSH Rd, Rm  | Rd[15:8] := Rm[7:0], Rd[7:0] := Rm[15:8], Rd[31:16] := Rm[7] * &FFFF   | N     |
| <b>Select</b>                   | Select bytes   | 6                    | SEL Rd, Rn, Rm  | Rd[7:0] := Rn[7:0] if GE[0] = 1, else Rd[7:0] := Rm[7:0]<br>Bits[15:8], [23:16], [31:24] selected similarly by GE[1], GE[2], GE[3]   |       |
| <b>If-Then</b>                  | If-Then  | T2                   | IT{pattern} {cond}  | Makes up to four following instructions conditional, according to pattern. pattern is a string of up to three letters. Each letter can be T (Then) or E (Else).<br>The first instruction after IT has condition cond. The following instructions have condition cond if the corresponding letter is T, or the inverse of cond if the corresponding letter is E.<br>See Table <b>Condition Field</b> for available condition codes. | T, U  |
| <b>Branch</b>                   | Branch   |                      | B <label>   | PC := label. label is this instruction ±32MB (T2: ±16MB, T: -252 - +256B)  | N, B  |
|                                 | with link  |                      | BL <label>  | LR := address of next instruction, PC := label. label is this instruction ±32MB (T2: ±16MB).   |       |
|                                 | and exchange   | 4T                   | BX Rm   | PC := Rm. Target is Thumb if Rm[0] is 1, ARM if Rm[0] is 0.  | N     |
|                                 | with link and exchange (1)                             | 5T                   | BLX <label>   | LR := address of next instruction, PC := label, Change instruction set.<br>label is this instruction ±32MB (T2: ±16MB).  | C     |
|                                 | with link and exchange (2) and change to Jazelle state | 5                    | BLX Rm  | LR := address of next instruction, PC := Rm[31:1]. Change to Thumb if Rm[0] is 1, to ARM if Rm[0] is 0.  | N     |
|                                 | and change to Jazelle state                            | 5J                   | BXJ Rm  | Change to Jazelle state if available   |       |
| Compare, branch if (non) zero   | T2   | CB{N}Z Rn, <label>   | If Rn {== or !=} 0 then PC := label. label is (this instruction + 4-130).                   | N,T,U  |       |
| Table Branch Byte               | T2   | TBB [Rn, Rm]         | PC = PC + ZeroExtend( Memory( Rn + Rm, 1) << 1 ). Branch range 4-512. Rn can be PC.         | T, U   |       |
| Table Branch Halfword           | T2   | TBH [Rn, Rm, LSL #1] | PC = PC + ZeroExtend( Memory( Rn + Rm << 1, 2) << 1 ). Branch range 4-131072. Rn can be PC. | T, U   |       |
| <b>Move to or from PSR</b>      | PSR to register  |                      | MRS Rd, <PSR>   | Rd := PSR  |       |
|                                 | register flags to APSR flags                           |                      | MSR APSR_<flags>, Rm  | APSR_<flags> := Rm   |       |
|                                 | immediate flags to APSR flags                          |                      | MSR APSR_<flags>, #<imm8m>  | APSR_<flags> := imm8_8r  |       |
|                                 | register to PSR  |                      | MSR <PSR>_<fields>, Rm  | PSR := Rm (selected bytes only)  |       |
|                                 | immediate to PSR                                       |                      | MSR <PSR>_<fields>, #<imm8m>  | PSR := imm8_8r (selected bytes only)   |       |
| <b>Processor state change</b>   | Change processor state                                 | 6                    | CPSID <iflags> {, #<p_mode>}  | Disable specified interrupts, optional change mode.  | U, N  |
|                                 |  | 6                    | CPSIE <iflags> {, #<p_mode>}  | Enable specified interrupts, optional change mode.   | U, N  |
|                                 | Change processor mode                                  | 6                    | CPS #<p_mode>   |  | U     |
|                                 | Set endianness   | 6                    | SETEND <endianness>   | Sets endianness for loads and stores. <endianness> can be BE (Big Endian) or LE (Little Endian).   | U, N  |

# ARM and Thumb-2 Instruction Set

## Quick Reference Card

| Single data item loads and stores    |                         | §  | Assembler                                 | Action if <op> is LDR                  | Action if <op> is STR                  | Notes |
|--------------------------------------|-------------------------|----|---|--|--|-------|
| Load or store word, byte or halfword | Immediate offset        |    | <op>{size}{T} Rd, [Rn {, #<offset>}]{!}   | Rd := [address, size]                  | [address, size] := Rd                  | 1, N  |
|                                      | Post-indexed, immediate |    | <op>{size}{T} Rd, [Rn], #<offset>         | Rd := [address, size]                  | [address, size] := Rd                  | 2     |
|                                      | Register offset         |    | <op>{size} Rd, [Rn, +/-Rm {, <opsh>}]{!}  | Rd := [address, size]                  | [address, size] := Rd                  | 3, N  |
|                                      | Post-indexed, register  |    | <op>{size}{T} Rd, [Rn], +/-Rm {, <opsh>}  | Rd := [address, size]                  | [address, size] := Rd                  | 4     |
|                                      | PC-relative             |    | <op>{size} Rd, <label>                    | Rd := [label, size]                    | Not available                          | 5, N  |
| Load or store doubleword             | Immediate offset        | 5E | <op>D Rd1, Rd2, [Rn {, #<offset>}]{!}     | Rd1 := [address], Rd2 := [address + 4] | [address] := Rd1, [address + 4] := Rd2 | 6, 9  |
|                                      | Post-indexed, immediate | 5E | <op>D Rd1, Rd2, [Rn], #<offset>           | Rd1 := [address], Rd2 := [address + 4] | [address] := Rd1, [address + 4] := Rd2 | 6, 9  |
|                                      | Register offset         | 5E | <op>D Rd1, Rd2, [Rn, +/-Rm {, <opsh>}]{!} | Rd1 := [address], Rd2 := [address + 4] | [address] := Rd1, [address + 4] := Rd2 | 7, 9  |
|                                      | Post-indexed, register  | 5E | <op>D Rd1, Rd2, [Rn], +/-Rm {, <opsh>}    | Rd1 := [address], Rd2 := [address + 4] | [address] := Rd1, [address + 4] := Rd2 | 7, 9  |
|                                      | PC-relative             | 5E | <op>D Rd1, Rd2, <label>                   | Rd1 := [label], Rd2 := [label + 4]     | Not available                          | 8, 9  |

| Preload data or instruction |                  | §(PLD) | §(PLI) | §(PLDW) | Assembler                   | Action if <op> is PLD        | Action if <op> is PLI               | Action if <op> is PLDW                | Notes |
|-----------------------------|------------------|--------|--------|---------|-----------------------------|------------------------------|-------------------------------------|---------------------------------------|-------|
|                             | Immediate offset | 5E     | 7      | 7MP     | <op> [Rn {, #<offset>}]     | Preload [address, 32] (data) | Preload [address, 32] (instruction) | Preload to Write [address, 32] (data) | 1, C  |
|                             | Register offset  | 5E     | 7      | 7MP     | <op> [Rn, +/-Rm {, <opsh>}] | Preload [address, 32] (data) | Preload [address, 32] (instruction) | Preload to Write [address, 32] (data) | 3, C  |
|                             | PC-relative      | 5E     | 7      |         | <op> <label>                | Preload [label, 32] (data)   | Preload [label, 32] (instruction)   |                                       | 5, C  |

| Other memory operations |  | §              | Assembler                              | Action  | Notes |
|-------------------------|--|----------------|--|---|-------|
| Load multiple           | Block data load                        |                | LDM{IA IB DA DB} Rn{!}, <reglist-PC>   | Load list of registers from [Rn]  | N, I  |
|                         | return (and exchange) and restore CPSR |                | LDM{IA IB DA DB} Rn{!}, <reglist+PC>   | Load registers, PC := [address][31:1] (§ 5T: Change to Thumb if [address][0] is 1)  | I     |
|                         | User mode registers                    |                | LDM{IA IB DA DB} Rn{!}, <reglist+PC>^  | Load registers, branch (§ 5T: and exchange), CPSR := SPSR. Exception modes only.  | I     |
|                         |  |                | LDM{IA IB DA DB} Rn, <reglist-PC>^     | Load list of User mode registers from [Rn]. Privileged modes only.  | I     |
| Pop                     |  | POP <reglist>  | Canonical form of LDM SP!, <reglist>   | N   |       |
| Load exclusive          | Semaphore operation                    | 6              | LDREX Rd, [Rn]                         | Rd := [Rn], tag address as exclusive access. Outstanding tag set if not shared address. Rd, Rn not PC.                            |       |
|                         | Halfword or Byte                       | 6K             | LDREX(H B) Rd, [Rn]                    | Rd[15:0] := [Rn] or Rd[7:0] := [Rn], tag address as exclusive access. Outstanding tag set if not shared address. Rd, Rn not PC.   |       |
|                         | Doubleword                             | 6K             | LDREXD Rd1, Rd2, [Rn]                  | Rd1 := [Rn], Rd2 := [Rn+4], tag addresses as exclusive access. Outstanding tags set if not shared addresses. Rd1, Rd2, Rn not PC. | 9     |
| Store multiple          | Push, or Block data store              |                | STM{IA IB DA DB} Rn{!}, <reglist>      | Store list of registers to [Rn]   | N, I  |
|                         | User mode registers                    |                | STM{IA IB DA DB} Rn{!}, <reglist>^     | Store list of User mode registers to [Rn]. Privileged modes only.   | I     |
| Push                    |  | PUSH <reglist> | Canonical form of STMDB SP!, <reglist> | N   |       |
| Store exclusive         | Semaphore operation                    | 6              | STREX Rd, Rm, [Rn]                     | If allowed, [Rn] := Rm, clear exclusive tag, Rd := 0. Else Rd := 1. Rd, Rm, Rn not PC.  |       |
|                         | Halfword or Byte                       | 6K             | STREX(H B) Rd, Rm, [Rn]                | If allowed, [Rn] := Rm[15:0] or [Rn] := Rm[7:0], clear exclusive tag, Rd := 0. Else Rd := 1. Rd, Rm, Rn not PC.                   |       |
|                         | Doubleword                             | 6K             | STREXD Rd, Rm1, Rm2, [Rn]              | If allowed, [Rn] := Rm1, [Rn+4] := Rm2, clear exclusive tags, Rd := 0. Else Rd := 1. Rd, Rm1, Rm2, Rn not PC.                     | 10    |
| Clear exclusive         |  | 6K             | CLREX                                  | Clear local processor exclusive tag   | C     |

### Notes: availability and range of options for Load, Store, and Preload operations

| Note | ARM Word, B, D                               | ARM SB, H, SH          | ARM T, BT                | Thumb-2 Word, B, SB, H, SH, D                              | Thumb-2 T, BT, SBT, HT, SHT              |
|------|--|------------------------|--------------------------|--|--|
| 1    | offset: -4095 to +4095                       | offset: -255 to +255   | Not available            | offset: -255 to +255 if writeback, -255 to +4095 otherwise | offset: 0 to +255, writeback not allowed |
| 2    | offset: -4095 to +4095                       | offset: -255 to +255   | offset: -4095 to +4095   | offset: -255 to +255                                       | Not available                            |
| 3    | Full range of {, <opsh>}                     | {, <opsh>} not allowed | Not available            | <opsh> restricted to LSL #<sh>, <sh> range 0 to 3          | Not available                            |
| 4    | Full range of {, <opsh>}                     | {, <opsh>} not allowed | Full range of {, <opsh>} | Not available  | Not available                            |
| 5    | label within +/- 4092 of current instruction | Not available          | Not available            | label within +/- 4092 of current instruction               | Not available                            |
| 6    | offset: -255 to +255                         | -                      | -                        | offset: -1020 to +1020, must be multiple of 4.             | -  |
| 7    | {, <opsh>} not allowed                       | -                      | -                        | Not available  | -  |
| 8    | label within +/- 252 of current instruction  | -                      | -                        | Not available  | -  |
| 9    | Rd1 even, and not r14, Rd2 == Rd1 + 1.       | -                      | -                        | Rd1 != PC, Rd2 != PC                                       | -  |
| 10   | Rm1 even, and not r14, Rm2 == Rm1 + 1.       | -                      | -                        | Rm1 != PC, Rm2 != PC                                       | -  |

# ARM and Thumb-2 Instruction Set

## Quick Reference Card

| Coprocessor operations                | §  | Assembler   | Action  | Notes                     |
|---------------------------------------|----|---|---|---------------------------|
| Data operations                       |    | CDP{2} <copr>, <op1>, CRd, CRn, CRm{, <op2>}      |   | Coprocessor defined<br>C2 |
| Move to ARM register from coprocessor |    | MRC{2} <copr>, <op1>, Rd, CRn, CRm{, <op2>}       |   | Coprocessor defined<br>C2 |
| Two ARM register move                 | 5E | MRRC <copr>, <op1>, Rd, Rn, CRm                   |   | Coprocessor defined       |
| Alternative two ARM register move     | 6  | MRRC2 <copr>, <op1>, Rd, Rn, CRm                  |   | Coprocessor defined<br>C  |
| Move to coproc from ARM reg           |    | MCR{2} <copr>, <op1>, Rd, CRn, CRm{, <op2>}       |   | Coprocessor defined<br>C2 |
| Two ARM register move                 | 5E | MCRR <copr>, <op1>, Rd, Rn, CRm                   |   | Coprocessor defined       |
| Alternative two ARM register move     | 6  | MCRR2 <copr>, <op1>, Rd, Rn, CRm                  |   | Coprocessor defined<br>C  |
| Loads and stores, pre-indexed         |    | <op>{2} <copr>, CRd, [Rn, #+/-<offset8*4>]{!}     | op: LDC or STC. offset: multiple of 4 in range 0 to 1020. | Coprocessor defined<br>C2 |
| Loads and stores, zero offset         |    | <op>{2} <copr>, CRd, [Rn] {, 8-bit copro. option} | op: LDC or STC.   | Coprocessor defined<br>C2 |
| Loads and stores, post-indexed        |    | <op>{2} <copr>, CRd, [Rn], #+/-<offset8*4>        | op: LDC or STC. offset: multiple of 4 in range 0 to 1020. | Coprocessor defined<br>C2 |

| Miscellaneous operations            | §  | Assembler                         | Action   | Notes |
|-------------------------------------|----|-----------------------------------|--|-------|
| <b>Swap word</b>                    |    | SWP Rd, Rm, [Rn]                  | temp := [Rn], [Rn] := Rm, Rd := temp.  | A, D  |
| <b>Swap byte</b>                    |    | SWPB Rd, Rm, [Rn]                 | temp := ZeroExtend([Rn][7:0]), [Rn][7:0] := Rm[7:0], Rd := temp                            | A, D  |
| <b>Return return state</b>          | 6  | SRS{IA IB DA DB} SP{!}, #<p_mode> | [SPm] := LR, [SPm + 4] := CPSR   | C, I  |
| <b>Return from exception</b>        | 6  | RFE{IA IB DA DB} Rn{!}            | PC := [Rn], CPSR := [Rn + 4]   | C, I  |
| <b>Breakpoint</b>                   | 5  | BKPT <imm16>                      | Prefetch abort or enter debug state. 16-bit bitfield encoded in instruction.               | C, N  |
| <b>Secure Monitor Call</b>          | Z  | SMC <imm4>                        | Secure Monitor Call exception. 4-bit bitfield encoded in instruction. Formerly SMI.        |       |
| <b>Supervisor Call</b>              |    | SVC <imm24>                       | Supervisor Call exception. 24-bit bitfield encoded in instruction. Formerly SWI.           | N     |
| <b>No operation</b>                 | 6K | NOP                               | None, might not even consume any time.   | N, V  |
| <b>Hints</b>                        |    |                                   |  |       |
| Debug Hint                          | 7  | DBG                               | Provide hint to debug and related systems.   |       |
| Data Memory Barrier                 | 7  | DMB                               | Ensure the order of observation of memory accesses.  | C     |
| Data Synchronization Barrier        | 7  | DSB                               | Ensure the completion of memory accesses,  | C     |
| Instruction Synchronization Barrier | 7  | ISB                               | Flush processor pipeline and branch prediction logic.                                      | C     |
| Set event                           | 6K | SEV                               | Signal event in multiprocessor system. NOP if not implemented.                             | N     |
| Wait for event                      | 6K | WFE                               | Wait for event, IRQ, FIQ, Imprecise abort, or Debug entry request. NOP if not implemented. | N     |
| Wait for interrupt                  | 6K | WFI                               | Wait for IRQ, FIQ, Imprecise abort, or Debug entry request. NOP if not implemented.        | N     |
| Yield                               | 6K | YIELD                             | Yield control to alternative thread. NOP if not implemented.                               | N     |

| Notes     |  |
|-----------|--|
| <b>A</b>  | Not available in Thumb state.  |
| <b>B</b>  | Can be conditional in Thumb state without having to be in an IT block.   |
| <b>C</b>  | Condition codes are not allowed in ARM state.  |
| <b>C2</b> | The optional 2 is available from ARMv5. It provides an alternative operation. Condition codes are not allowed for the alternative form in ARM state.                         |
| <b>D</b>  | Deprecated. Use LDREX and STREX instead.   |
| <b>G</b>  | Updates the four GE flags in the CPSR based on the results of the individual operations.   |
| <b>I</b>  | IA is the default, and is normally omitted.  |
| <b>L</b>  | ARM: <imm8m>. 16-bit Thumb: multiple of 4 in range 0-1020. 32-bit Thumb: 0-4095.   |
| <b>N</b>  | Some or all forms of this instruction are 16-bit (Narrow) instructions in Thumb-2 code. For details see the <i>Thumb 16-bit Instruction Set (UAL) Quick Reference Card</i> . |
| <b>P</b>  | Rn can be the PC in Thumb state in this instruction.   |
| <b>Q</b>  | Sets the Q flag if saturation (addition or subtraction) or overflow (multiplication) occurs. Read and reset the Q flag using MRS and MSR.                                    |
| <b>R</b>  | <sh> range is 1-32 in the ARM instruction.   |
| <b>S</b>  | The S modifier is not available in the Thumb-2 instruction.  |
| <b>T</b>  | Not available in ARM state.  |
| <b>U</b>  | Not allowed in an IT block. Condition codes not allowed in either ARM or Thumb state.  |
| <b>V</b>  | The assembler inserts a suitable instruction if the NOP instruction is not available.  |

# ARM and Thumb-2 Instruction Set

## Quick Reference Card

| ARM architecture versions |  |
|---------------------------|--|
| <i>n</i>                  | ARM architecture version <i>n</i> and above                    |
| <i>n</i> T, <i>n</i> J    | T or J variants of ARM architecture version <i>n</i> and above |
| 5E                        | ARM v5E, and 6 and above                                       |
| T2                        | All Thumb-2 versions of ARM v6 and above                       |
| 6K                        | ARMv6K and above for ARM instructions, ARMv7 for Thumb         |
| 7MP                       | ARMv7 architectures that implement Multiprocessing Extensions  |
| Z                         | All Security extension versions of ARMv6 and above             |
| RM                        | ARMv7-R and ARMv7-M only                                       |
| XS                        | XScale coprocessor instruction                                 |

| Flexible Operand 2                                   |         |            |
|--|---------|------------|
| Immediate value                                      |         | #<imm8m>   |
| Register, optionally shifted by constant (see below) | Rm      | {, <opsh>} |
| Register, logical shift left by register             | Rm, LSL | Rs         |
| Register, logical shift right by register            | Rm, LSR | Rs         |
| Register, arithmetic shift right by register         | Rm, ASR | Rs         |
| Register, rotate right by register                   | Rm, ROR | Rs         |

| Register, optionally shifted by constant |                  |                     |
|--|------------------|---------------------|
| (No shift)                               | Rm               | Same as Rm, LSL #0  |
| Logical shift left                       | Rm, LSL #<shift> | Allowed shifts 0-31 |
| Logical shift right                      | Rm, LSR #<shift> | Allowed shifts 1-32 |
| Arithmetic shift right                   | Rm, ASR #<shift> | Allowed shifts 1-32 |
| Rotate right                             | Rm, ROR #<shift> | Allowed shifts 1-31 |
| Rotate right with extend                 | Rm, RRX          |                     |

| PSR fields (use at least one suffix) |                           |            |
|--------------------------------------|---------------------------|------------|
| Suffix                               | Meaning                   |            |
| c                                    | Control field mask byte   | PSR[7:0]   |
| f                                    | Flags field mask byte     | PSR[31:24] |
| s                                    | Status field mask byte    | PSR[23:16] |
| x                                    | Extension field mask byte | PSR[15:8]  |

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| Condition Field |                                     |                                      |
|-----------------|-------------------------------------|--------------------------------------|
| Mnemonic        | Description                         | Description (VFP)                    |
| EQ              | Equal                               | Equal                                |
| NE              | Not equal                           | Not equal, or unordered              |
| CS / HS         | Carry Set / Unsigned higher or same | Greater than or equal, or unordered  |
| CC / LO         | Carry Clear / Unsigned lower        | Less than                            |
| MI              | Negative                            | Less than                            |
| PL              | Positive or zero                    | Greater than or equal, or unordered  |
| VS              | Overflow                            | Unordered (at least one NaN operand) |
| VC              | No overflow                         | Not unordered                        |
| HI              | Unsigned higher                     | Greater than, or unordered           |
| LS              | Unsigned lower or same              | Less than or equal                   |
| GE              | Signed greater than or equal        | Greater than or equal                |
| LT              | Signed less than                    | Less than, or unordered              |
| GT              | Signed greater than                 | Greater than                         |
| LE              | Signed less than or equal           | Less than or equal, or unordered     |
| AL              | Always (normally omitted)           | Always (normally omitted)            |

All ARM instructions (except those with Note C or Note U) can have any one of these condition codes after the instruction mnemonic (that is, before the first space in the instruction as shown on this card). This condition is encoded in the instruction.

All Thumb-2 instructions (except those with Note U) can have any one of these condition codes after the instruction mnemonic. This condition is encoded in a preceding IT instruction (except in the case of conditional Branch instructions). Condition codes in instructions must match those in the preceding IT instruction.

On processors without Thumb-2, the only Thumb instruction that can have a condition code is B <label>.

| Processor Modes |                    |
|-----------------|--------------------|
| 16              | User               |
| 17              | FIQ Fast Interrupt |
| 18              | IRQ Interrupt      |
| 19              | Supervisor         |
| 23              | Abort              |
| 27              | Undefined          |
| 31              | System             |

| Prefixes for Parallel Instructions |  |
|------------------------------------|--|
| S                                  | Signed arithmetic modulo 2 <sup>8</sup> or 2 <sup>16</sup> , sets CPSR GE bits   |
| Q                                  | Signed saturating arithmetic   |
| SH                                 | Signed arithmetic, halving results   |
| U                                  | Unsigned arithmetic modulo 2 <sup>8</sup> or 2 <sup>16</sup> , sets CPSR GE bits |
| UQ                                 | Unsigned saturating arithmetic   |
| UH                                 | Unsigned arithmetic, halving results   |

### Document Number

ARM QRC 0001M

### Change Log

| Issue | Date       | Change          | Issue | Date       | Change         |
|-------|------------|-----------------|-------|------------|----------------|
| A     | June 1995  | First Release   | B     | Sept 1996  | Second Release |
| C     | Nov 1998   | Third Release   | D     | Oct 1999   | Fourth Release |
| E     | Oct 2000   | Fifth Release   | F     | Sept 2001  | Sixth Release  |
| G     | Jan 2003   | Seventh Release | H     | Oct 2003   | Eighth Release |
| I     | Dec 2004   | Ninth Release   | J     | May 2005   | RVCT 2.2 SP1   |
| K     | March 2006 | RVCT 3.0        | L     | March 2007 | RVCT 3.1       |
| M     | Sept 2008  | RVCT 4.0        |       |            |                |