Arm® Fortran Compiler

Version 22.0.2

Developer and Reference Guide

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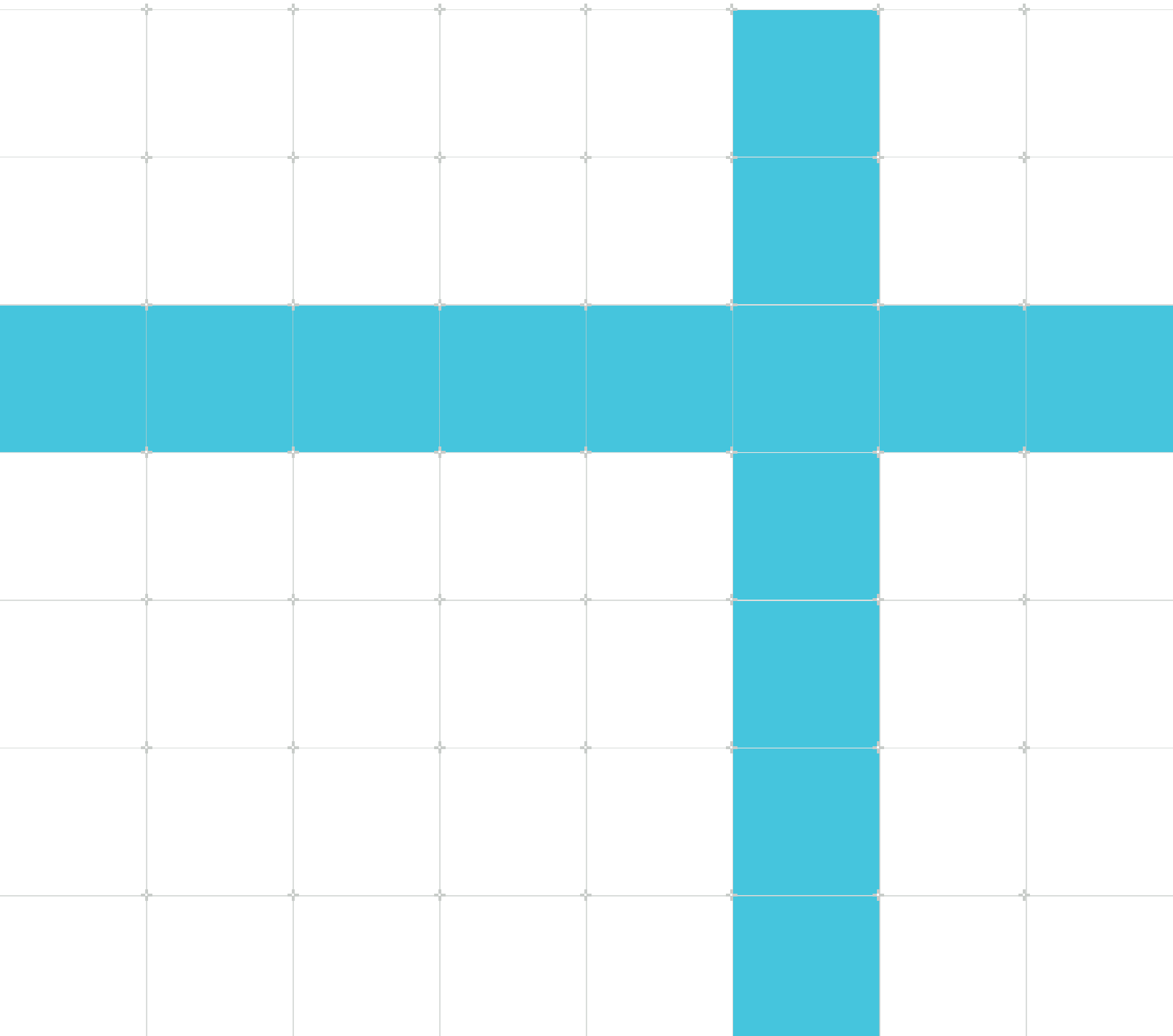

Arm® Fortran Compiler

Developer and Reference Guide

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1 Introduction

Provides information to help you use the Arm® Fortran Compiler component of Arm® Compiler for Linux. Arm® Fortran Compiler is an auto-vectorizing, Linux user-space Fortran compiler, tailored for Server and High Performance Computing (HPC) workloads. Arm® Fortran Compiler supports popular Fortran and OpenMP standards and is tuned for Arm®v8-A based processors.

1.1 Conventions

The following subsections describe conventions used in Arm documents.

Glossary

The Arm Glossary is a list of terms used in Arm documentation, together with definitions for those terms. The Arm Glossary does not contain terms that are industry standard unless the Arm meaning differs from the generally accepted meaning.

See the Arm® Glossary for more information: developer.arm.com/glossary.

Typographic conventions

Arm documentation uses typographical conventions to convey specific meaning.

Convention	Use
italic	Citations.
bold	Interface elements, such as menu names. Signal names. Terms in descriptive lists, where appropriate.
`monospace`	Text that you can enter at the keyboard, such as commands, file and program names, and source code.
`monospace bold`	Language keywords when used outside example code.
`monospace underline`	A permitted abbreviation for a command or option. You can enter the underlined text instead of the full command or option name.
`<and>`	Encloses replaceable terms for assembler syntax where they appear in code or code fragments. For example: `MRC p15, 0, <Rd>, <CRn>, <CRm>, <Opcode_2>`
SMALL CAPITALS	Terms that have specific technical meanings as defined in the *Arm® Glossary*. For example, **IMPLEMENTATION DEFINED**, **IMPLEMENTATION SPECIFIC**, **UNKNOWN**, and **UNPREDICTABLE**.
Caution	Recommendations. Not following these recommendations might lead to system failure or damage.
Warning	Requirements for the system. Not following these requirements might result in system failure or damage.

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Convention	Use
	Requirements for the system. Not following these requirements will result in system failure or damage.
	An important piece of information that needs your attention.
	A useful tip that might make it easier, better or faster to perform a task.
	A reminder of something important that relates to the information you are reading.

1.2 Other information

See the Arm website for other relevant information.

- Arm® Developer.
- Arm® Documentation.
- Technical Support.
- Arm® Glossary.

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2 Get started

This chapter introduces Arm® Fortran Compiler (part of Arm Compiler for Linux), and describes how to get started with the compiler.

2.1 Arm Fortran Compiler

Arm® Fortran Compiler is a Linux user space Fortran compiler for server and High Performance Computing (HPC) Arm-based platforms. Arm Fortran Compiler is built on the open-source Clang front-end and the LLVM 13.0.0-based optimization and code generation back-end.

Arm Fortran Compiler supports modern Fortran (see Fortran 2003 and Fortran 2008), OpenMP 4.0, and OpenMP 4.5 standards, has a built-in autovectorizer, and is tuned for the 64-bit Arm architecture. Arm Fortran Compiler also supports compiling for Scalable Vector Extension- (SVE-) and SVE2-enabled.

Arm Fortran Compiler is packaged with Arm C/C++ Compiler and Arm Performance Libraries in a single package called Arm Compiler for Linux.

Resources

To learn more about Arm Fortran Compiler (part of Arm Compiler for Linux) and other Arm server and HPC tools, refer to the following information:

- **Arm Compiler for Linux**:
  - Arm Fortran Compiler web page
  - Installation instructions
  - Release history
  - Supported platforms
- **Porting guidance**:
  - Porting and tuning resources
  - Arm GitLab Packages wiki
  - Arm HPC Ecosystem
- **SVE and SVE2 information**:
  - Scalable Vector Extension (SVE, and SVE2) information
  - For an overview of SVE and why it is useful for HPC, see Explore the Scalable Vector Extension (SVE).
  - For a list of SVE and SVE2 instructions, see the Arm A64 Instruction Set Architecture.
  - White Paper: A sneak peek into SVE and VLA programming. An overview of SVE with information on the new registers, the new instructions, and the Vector Length Agnostic (VLA) programming technique, with some examples.

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  - White Paper: Arm Scalable Vector Extension and application to Machine Learning. In this white paper, code examples are presented that show how to vectorize some of the core computational kernels that are part of a machine learning system. These examples are written with the Vector Length Agnostic (VLA) approach introduced by the Scalable Vector Extension (SVE).
  - DWARF for the ARM® 64-bit Architecture (AArch64) with SVE support. This document describes the use of the DWARF debug table format in the Application Binary Interface (ABI) for the Arm 64-bit architecture.
  - Procedure Call Standard for the ARM 64-bit Architecture (AArch64) with SVE support. This document describes the Procedure Call Standard use by the Application Binary Interface (ABI) for the Arm 64-bit architecture.
  - Arm Architecture Reference Manual Supplement - The Scalable Vector Extension (SVE), for ARMv8-A. This supplement describes the Scalable Vector Extension to the Armv8-A architecture profile.
- **Support and sales**:
  - If you encounter a problem when developing your application and compiling with the Arm Fortran Compiler, see the Troubleshoot
  - Get software

An HTML version of this guide is available in the `<install_location>/<package_name>/share` directory of your product installation.

2.2 Get started with Arm Fortran Compiler

Describes how to download and install Arm® Compiler for Linux, and how to use Arm Fortran Compiler to compile Fortran source into an executable binary.

Before you begin

Download and install Arm Compiler for Linux. You can download Arm Compiler for Linux from the download page. Learn how to install and configure Arm Compiler for Linux, using the Arm Compiler for Linux installation instructions on the Arm Developer website.

Procedure

1. Load the environment module for Arm Compiler for Linux:
   a) As part of the installation, Arm recommends that your system administrator makes the Arm Compiler for Linux environment modules available to all users of the tool suite.
   To see which environment modules are available on your system, run:

```
module avail
```

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If you cannot see the Arm Compiler for Linux environment module, but you know the installation location, use `module use` to update your `MODULEPATH` environment variable to include that location:


```
module use <path/to/installation>/modulefiles/
```

replacing `<path/to/installation>` with the path to your installation of Arm Compiler for Linux. The default installation location is `/opt/arm/`.

`module use` sets your `MODULEPATH` environment variable to include the installation directory:

b) To load the module for Arm Compiler for Linux, run:

```
module load acfl/<package-version>
```

where `<package-version>` is `<major-version>.<minor-version>{.<patch-version>}`.

For example:

```
module load acfl/22.0.2
```

c) Check your environment. Examine the `PATH` variable. `PATH` must contain the appropriate `bin` directory from `<path/to/installation>`:

```
echo $PATH
/opt/arm/arm-linux-compiler-22.0.2_Generic-AArch64_SUSE-15_aarch64-linux/
bin:...
```

To automatically load the Arm Compiler for Linux every time you log into your Linux terminal, add the `module load` command for your system and product version to your `.profile` file.

2. To generate an executable binary, compile your application with Arm Fortran Compiler. Specify the input source filename, `<source>.<fortran-extension>`, and use `-o` to specify the output binary file, `<binary>`:

```
armflang -o <binary> <source>.<fortran-extension>
```

Results

Arm Fortran Compiler builds your binary `<binary>`.

To run your binary, use:

```
./<binary>
```

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Example 2-1: Example: Compile and run a "Hello World" application

This example describes how to write, compile, and run a simple "Hello World" Fortran application.

1. Load the environment module for your system:

   ```
   module load acfl/<package-version>
   ```

   where `<package-version>` is `<major-version>.<minor-version>{.<patch-version>}`.

   For example:

   ```
   module load acfl/22.0.2
   ```

2. Create a "Hello World" application and save it in an `.f90` file, for example: `hello.f90`:

   ```
   program hello
     print *, 'hello world'
   end program
   ```

3. To generate an executable binary, compile your "Hello World" application with Arm Fortran Compiler.

   Specify the input file, `hello.f90`, and the binary name (using `-o`), `hello`:

   ```
   armflang -o hello hello.f90
   ```

4. Run the generated binary `hello`:

   ```
   ./hello
   ```

Next steps

For more information about compiling and linking as separate steps, and how optimization levels effect auto-vectorization, see Compile and link.

2.3 Use Arm Compiler for Linux securely in shared environments

Arm® Compiler for Linux provides features and language support in common with other toolchains. Misuse of these common features and language support can provide access to arbitrary files, execute system commands, and reveal the contents of environment variables.

If you deploy Arm Compiler for Linux into environments where security is a concern, then Arm strongly recommends that you do all of the following:

- To limit tool access to only the necessary files, sandbox the tools.
- Remove all non-essential environment variables.

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- Prevent execution of other binaries.
- Segregate different users from one another.
- Limit execution time.

2.4 Get support

To see a list of all the supported compiler options in your terminal, use:

```
armflang --help
```

or

```
man armflang
```

A description of each supported command-line option is available in Compiler options.

If you encounter a problem when developing your application and compiling with the Arm® Compiler for Linux, see the Troubleshoot topic.

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3 Compile and link

This chapter describes the basic functionality of Arm® Fortran Compiler, and describes how to compile your Fortran source with `armflang`.

3.1 Using the compiler

Describes how to generate executable binaries, compile and link object files, and enable optimization options, with Arm® Fortran Compiler.

Compile and link

To generate an executable binary, compile your source file (for example, `source.f90`) with the `armflang` command:

```
armflang -o source.f90
```

A binary with the filename `source` is output.

Optionally, use the `-o` option to set the binary filename (for example, `binary`):

```
armflang -o binary source.f90
```

You can specify multiple source files on a single line. Each source file is compiled individually and then linked into a single executable binary. For example, to compile the source files `source1.f90` and `source2.f90`, use:

```
armflang -o binary source1.f90 source2.f90
```

To compile each of your source files individually into an object file, specify the compile-only option, `-c`, and then pass the resulting object files into another invocation of `armflang` to link them into an executable binary.

```
armflang -c source1.f90
armflang -c source2.f90
armflang -o binary source1.o source2.o
```

Increase the optimization level

To control the optimization level, specify the `-O<level>` option on your compile line, and replace `<level>` with one of `0`, `1`, `2`, `3`, or `fast`. `-O0` option is the lowest, and the default, optimization level. `-Ofast` is the highest optimization level. Arm Fortran Compiler performs auto-vectorization at levels `-O2`, `03`, and `-Ofast`.

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For example, to compile `source.f90` into a binary called `binary`, and use the `-O3` optimization level, use:

```
armflang -O3 -o binary source.f90
```

Compile and optimize using CPU auto-detection

If you tell Arm Fortran Compiler what target CPU your application will run on, the compiler can make target-specific optimization decisions. Target-specific optimization decisions help ensure your application runs as efficiently as possible. To tell the compiler to make target-specific compilation decisions, use the `-mcpu=<target>` option and replace `<target>` with your target processor (from a supported list of targets). To see what processors are supported by the `-mcpu` option, see -mcpu=.

In addition, the `-mcpu` option also supports a `native` argument. `-mcpu=native` enables Arm Fortran Compiler to auto-detect the architecture and processor type of the CPU that you are running the compiler on.

For example, to auto-detect the target CPU and optimize the application for this target, use:

```
armflang -O3 -mcpu=native -o binary source.f90
```

The `-mcpu` option supports a range of Armv8-A-based Systems-on-Chips (SoCs), including: ThunderX2, Neoverse N1, Neoverse N2, Neoverse V1, and A64FX. When `-mcpu` is not specified, by default, `-mcpu=generic` is set, which generates portable output suitable for any Armv8-A-based target.

- The optimizations that are performed from setting the `-mcpu` option (also known as hardware, or CPU, tuning) are independent of the optimizations that are performed from setting the `-O<level>` option.
- If you run the compiler on one target, but will run the application you are compiling on a different target, do not use `-mcpu=native`. Instead, use `-mcpu=<target>` where `<target>` is the target processor that you will run the application on.

Link to a math library

You can get greater performance from your code if you enable linking to optimized math libraries at compilation time.

To enable you to get the best performance on Arm-based systems, Arm recommends linking to Arm Performance Libraries. Arm Performance Libraries provide optimized standard core math libraries for high-performance computing applications on Arm processors. Through a Fortran interface, the following types of routines are available:

- BLAS: Basic Linear Algebra Subprograms (including XBLAS, the extended precision BLAS).
- LAPACK: A comprehensive package of higher level linear algebra routines. To find out what the latest version of LAPACK that is supported in Arm Performance Libraries is, see Arm Performance Libraries.

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- FFT functions: A set of Fast Fourier Transform routines for real and complex data using the FFTW interface.
- Sparse linear algebra
- libamath: A subset of libm, which is a set of optimized mathematical functions.
- libastring: A subset of libc, which is a set of optimized string functions.

To instruct Arm Fortran Compiler to use the optimum version of Arm Performance Libraries for your target architecture and implementation, you can use the `-armpl=` compiler option. `-armpl=` enables the tuned scalar and vector implementations of Fortran math intrinsics, and auto-vectorization of mathematical functions (which can be disabled using `-fno-simdmath`). `-armpl=` supports arguments which enable you to use 32- or 64-bit integers, and either the serial library or the OpenMP multi-threaded library.

For example:

- To link to the OpenMP multi-threaded Arm Performance Libraries with a 64-bit integer interface, and include compiler and library optimizations for an A64FX-based system, use:

```
armflang code_with_math_routines.f90 -armpl=ilp64,parallel -mcpu=a64fx
```

- To link to the OpenMP multi-threaded Arm Performance Libraries with a 32-bit integer interface, and build portable output that is suitable for any Armv8-A-based system, use:

```
armflang code_with_math_routines.f90 -armpl -fopenmp -mcpu=generic
```

- To link to the serial implementation of Arm Performance Libraries with a 32-bit integer interface, and include compiler and library optimizations for a Neoverse N1-based system, use:

```
armflang code_with_math_routines.f90 -armpl=lp64,sequential -mcpu=neoverse-n1
```

For a full list of supported arguments for `-armpl`, see doc:*../compiler-options/armflang-Optimization_Group-armpl_EQ*.

If you want to link to another custom library, you can specify the library to `armflang` using the `-l<library>` compiler option. For more information, see -l.

Common compiler options

This section describes some common options to use with Arm Fortran Compiler.

For more information about all the supported compiler options, run `man armflang`, `armflang --help`, or see Compiler options.

`-S`

Outputs assembly code, rather than object code. Produces a text `.s` file containing annotated assembly code.

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-c

Performs the compilation step, but does not perform the link step. Produces an Executable and Linkable Format (ELF) object file (`<file>.o`). To later link object files into an executable binary, run `armflang` again, passing in the object files.

-o <file>

Specifies the name of the output file.

-march=name[+[no]feature]

Targets an architecture profile, generating generic code that runs on any processor of that architecture. For example `-march=armv8-a`, `-march=armv8-a+sve`, or `-march=armv8-a+sve2`.

If you know what your target CPU is, Arm recommends using the `-mcpu` option instead of `-march`. For a complete list of supported targets, see -march=.

-mcpu=native

Enables the compiler to automatically detect the CPU you are running the compiler on, and optimize accordingly. The compiler selects a suitable target profile for that CPU. If you use `-mcpu`, you do not need to use the `-march` option.

`-mcpu` supports a number of Armv8-A-based Systems-on-Chip (SoCs), including: ThunderX2, Neoverse N1, Neoverse N2, Neoverse V1, and A64FX.

When `-mcpu` is not specified, it defaults to `-mcpu=generic` which generates portable output suitable for any Armv8-A-based target.

For more information, see -mcpu=.

-O<level>

Specifies the level of optimization to use when compiling source files. The supported options are: `-O0`, `-O1`, `-O2`, `-O3`, and `-Ofast`. The default is `-O0`. Auto-vectorization is enabled at `-O2`, `-O3`, and `-Ofast`

`-Ofast` performs aggressive optimizations that might violate strict compliance with language standards.

For more information, see -O.

--config /path/to/<config-file>

Passes the location of a configuration file to the compile command. Use a configuration file to specify a set of compile options to be run at compile time. The configuration file can be passed at compile time, or an environment variable can be set for it to be used for every

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invocation of the compiler. For more information about creating and using a configuration file, see Configure Arm Compiler for Linux.

`--help`
Describes the most common options that are supported by Arm Fortran Compiler. To see more detailed descriptions of all the options, use `man armflang`.

`--version`
Displays version information.

For a detailed description of all the supported compiler options, see Compiler options.

To view the supported options on the command-line, use the `man` pages:

```
man armflang
```

Alternatively, if you use a bash terminal and have the 'bash-completion' package installed, you can use 'command line completion' (also known as 'tab completion'). To complete the command or option that you are typing in your terminal, press the **Tab** button on your keyboard. If there are multiple options available to complete the command or option with, the terminal presents these as a list. If an option is specified in full, and you press **Tab**, Arm Compiler for Linux returns the supported arguments to that option.

For more information about how command line completion is enabled for bash terminal users of Arm Compiler for Linux, see the installation instructions.

Related information

Compile Fortran code for Arm SVE and SVE2-enabled processors on page 25
Compiler options on page 58

3.2 Compile Fortran code for Arm SVE and SVE2-enabled processors

This topic describes how to use Arm® Fortran Compiler to compile your code for Scalable Vector Extension- (SVE-) and SVE2-enabled target processors.

Before you begin

- Ensure you have installed Arm Compiler for Linux.

  For information about installing Arm Compiler for Linux, see Install Arm Compiler for Linux.
- Ensure you have loaded the environment module for Arm Compiler for Linux. To load the environment module, run:

  ```
  module load acfl/<package-version>
  ```

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where `<package-version>` is `<major-version>.<minor-version>{.<patch-version>}`.

For example:

```
module load acfl/22.0.2
```

- Your target must be SVE- or SVE2-enabled hardware, or you must download, install, and load the correct environment module for Arm Instruction Emulator.

  For more information about installing and setting up your environment for Arm Instruction Emulator, see Install Arm Instruction Emulator.

About this task

SVE and SVE2 support enables you to:

- Assemble source code containing SVE and SVE2 instructions.
- Disassemble ELF object files containing SVE and SVE2 instructions.
- Compile Fortran code for SVE and SVE2-enabled targets, with an advanced auto-vectorizer that is capable of taking advantage of the SVE and SVE2 features.

This topic shows you how to compile code to take advantage of SVE (or SVE2) functionality. The generated executable can be run on SVE-enabled (or SVE2-enabled) hardware, or emulated using Arm Instruction Emulator.

Procedure

1. Compile your SVE or SVE2 source:
   - If you are both compiling and running on SVE-enabled (or SVE2-enabled) hardware, enable compiler optimizations using `-mcpu=native`.

     To compile SVE or SVE2 code without linking to Arm Performance Libraries, use:

     ```
     armflang -O<level> -mcpu=native -o <binary> <source.f90>
     ```

     To compile SVE or SVE2 code and link to Arm Performance Libraries, use:

     ```
     armflang -O<level> -mcpu=native -armpl -o <binary> <source.f90>
     ```

   - To compile SVE (or SVE2) code on hardware that is not SVE-enabled, but that will be run on SVE-enabled (or SVE2-enabled) hardware, specify your SVE-enabled (or SVE2-enabled) processor using `-mcpu=<target>`.

     To compile SVE or SVE2 code without linking to Arm Performance Libraries, use:

     ```
     armflang -O<level> -mcpu=<target> -o <binary> <source.f90>
     ```

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To compile SVE or SVE2 code and link to Arm Performance Libraries, use:

```
armflang -O<level> -mcpu=<target> -armpl -o <binary> <source.f90>
```

If you do not know the target processor, specify an SVE-enabled target architecture using `-march=armv8-a+sve` (or an SVE2-enabled target using `-march=armv8-a+sve2`), instead of using `-mcpu=<target>`.

- To compile SVE (or SVE2) code to emulate with Arm Instruction Emulator, compile the code and specify an SVE-enabled (or SVE2-enabled) architecture using `-march=`.

  To compile SVE code without linking to Arm Performance Libraries, use:

  ```
  armflang -O<level> -march=armv8-a+sve -o <binary> <source.f90>
  ```

  To compile SVE code and link to Arm Performance Libraries, use:

  ```
  armflang -O<level> -march=armv8-a+sve -armpl -o <binary> <source.f90>
  ```

  To compile SVE code for an Armv8.2-A-based target, and link to Arm Performance Libraries, use:

  ```
  armflang -O<level> -march=armv8.2-a+sve -armpl -o <binary> <source.f90>
  ```

  

  To compile SVE2 code, replace `+sve` with `+sve2` in the `-march` option argument.

For more information about the supported options for `-armpl`, for example to control using 32-bit or 64-bit integers, or to use the single or OpenMP multi-threaded library, see the `-armpl` description in -armpl=.

- To enable optimal vectorization, set `-O<level>` to be `-O2`, or higher.
- There are several SVE2 Cryptographic Extensions available: `sve2-aes`, `sve2-bitperm`, `sve2-sha3`, and `sve2-sm4`. Each extension is enabled using the `march` compiler option. For a full list of supported `-march` options, see -march=.
- `sve2` also enables `sve`.

2. Run the executable:

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- To run the executable on SVE-enabled (or SVE2-enabled) hardware, use:

```
./<binary>
```

- To run and emulate the instructions using Arm Instruction Emulator, use:

```
armie -msve-vector-bits=<value> ./<binary>
```

Replace `<value>` with the vector length to use (which must be a multiple of 128 bits up to 2048 bits).


Note

For more information about using Arm Instruction Emulator, see the Arm Instruction Emulator documentation.

Related information

-armpl= on page 62
-mcpu= on page 77
-march= on page 76
Learn about the Scalable Vector Extension (SVE)
Arm A64 Instruction Set Architecture
Porting and Optimizing HPC Applications for Arm SVE
White Paper: A sneak peek into SVE and VLA programming
White Paper: Arm Scalable Vector Extension and application to Machine Learning
DWARF for the ARM
Procedure Call Standard for the ARM 64-bit Architecture (AArch64) with SVE support
Arm Architecture Reference Manual Supplement - The Scalable Vector Extension (SVE), for ARMv8-A

3.3 Generate annotated assembly code

Arm® Fortran Compiler can produce annotated assembly code. Generating annotated assembly code is a good first step to see how the compiler vectorizes loops.

Before you begin

- Install Arm Compiler for Linux. For information about installing Arm Compiler for Linux, see Install Arm Compiler for Linux.
- Load the module for Arm Compiler for Linux, run:

```
module load acfl/<package-version>
```

where `<package-version>` is `<major-version>.<minor-version>{.<patch-version>}`.

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For example:

```
module load acfl/22.0.2
```

About this task

To use SVE functionality, you need to use a different set of compiler options. For more information, refer to Compile Fortran code for Arm SVE and SVE2-enabled processors.

Procedure

1. Compile your source and specify an assembly code output:

   ```
   armflang -S <source>.f90
   ```

   The option `-s` is used to output assembly code.

   The compiler outputs a `<source>.s` file.
2. Inspect the `<source>.s` file to see the annotated assembly code that was created.

Related information

Compile Fortran code for Arm SVE and SVE2-enabled processors on page 25

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4 Optimize

This chapter describes the optimization-specific features supported in Arm® Fortran Compiler.

4.1 Directives

Directives are used to provide additional information to the compiler, and to control the compilation of specific code blocks, for example, loops. This chapter describes what directives are supported in Arm® Fortran Compiler.

To specify a compiler directive in your source file, use:

- For free-form Fortran, use `!dir$` to indicate a directive, or `!$omp` to indicate an OpenMP directive.
- For fixed-form Fortran, either `!dir$` or `cdir$` can be used to indicate a directive, and either `!$omp` or `c$omp` can be used to indicate an OpenMP directive.

Directives using `cdir$` or `c$omp` must start from the first column.

To enable OpenMP directives, you must also include the `-fopenmp` compiler option in the compile command line.

For more information about which OpenMP directives are supported, see Standards support. For more information about the `-fopenmp` option, see -fopenmp.

4.1.1 ivdep

Apply this general-purpose directive to a loop to force the vectorizer to ignore memory dependencies of iterative loops, and proceed with the vectorization.

Syntax

Command-line option:

None

Source:

```
!dir$ ivdep
  <loops>
```

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Parameters

None

Example: Using ivdep

Example usage of the `ivdep` directive.

```
subroutine sum(myarr1,myarr2,ub)
    integer, pointer :: myarr1(:)
    integer, pointer :: myarr2(:)
    integer :: ub
    !dir$ ivdep
    do i=1,ub
        myarr1(i) = myarr1(i)+myarr2(i)
    end do
end subroutine
```


Note

The example uses the free-form syntax. For fixed-form formats, replace `!dir$` with `cdir$`.

Command-line invocation

```
armflang -c -O2 -Rpass-missed=loop-vectorize -Rpass=loop-vectorize -S <file>.f90
```

The `-Rpass` and `-Rpass-missed` options enable optimization remarks about vectorized loops to be reported. To learn more about optimization remarks, see Optimization remarks.

Outputs

1. With the pragma, the loop in the sum subroutine produces the following remark:

   ```
   remark vectorized loop (vectorization width: 2, interleaved
   count: 1) [-Rpass=loop-vectorize]
   ```

2. Without the pragma, the loop in the sum subroutine produces the following remark:

   ```
   remark: loop not vectorized [-Rpass-missed=loop-vectorize]
   ```

4.1.2 omp simd

Apply this OpenMP directive to a loop to indicate that the loop can be transformed into a SIMD loop.

Syntax

Command-line option:

```
-fopenmp
```

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Source:

```
!$omp simd
  <do-loops>
```

Parameters

None

Clauses for `omp simd` are not supported.

Example: Using omp simd

Example usage of the `omp simd` directive.

Code example:

```
subroutine sum(myarr1,myarr2,myarr3,myarr4,myarr5,ub)
    integer, pointer :: myarr1(:)
    integer, pointer :: myarr2(:)
    integer, pointer :: myarr3(:)
    integer, pointer :: myarr4(:)
    integer, pointer :: myarr5(:)
    integer :: ub
    !$omp simd
    do i=1,ub
        myarr1(i) = myarr2(myarr4(i))+myarr3(myarr5(i))
    end do
end subroutine
```

Command-line invocation

```
 armflang -c -O3 -fopenmp -Rpass-missed=loop-vectorize -Rpass=loop-vectorize -S
 <file>.f90
```

The `-Rpass` and `-Rpass-missed` options enable optimization remarks about vectorized loops to be reported. To learn more about optimization remarks, see Optimization remarks.

Outputs

1. With the pragma, the loop that is given below says the following:

   ```
   remark vectorized loop (vectorization width: 2, interleaved
   count: 1) [-Rpass=loop-vectorize]
   ```

2. Without the pragma, the loop that is given below says the following:

   ```
   remark: loop not vectorized [-Rpass-missed=loop-vectorize]
   ```

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Related information

-fopenmp on page 69
Standards support on page 118

4.1.3 prefetch

Tells the compiler to generate prefetch instructions to fetch elements and load them in the data cache, ahead of their first use. Users can provide a prefetch distance. Prefetching elements can improve performance by reducing main memory latency.

Syntax

Command-line option:

None

Source:

```
!$mem prefetch <var_1>[,<var_2>[,...]]
```

where `<var_n>` is any valid array element reference, member, or variable.

Parameters

None

Example: Using prefetch

The following example uses the `prefetch` directive to prefetch the value in array `x`, eight iterations before the value is used.

Code example:

```
program mn
  integer:: i
  integer :: x(100), y(100)
  integer :: a = 20
  do i=1,100
     !$mem prefetch x(i+8)
     y(i) = y(i) + a*x(i);
  end do
end program
```

4.1.4 unroll

Instructs the compiler optimizer to unroll a `DO` loop when optimization is enabled with an optimization level of `-O2`, `-O3`, or `-Ofast`.

Syntax

Command-line option:

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None

Source:

```
!dir$ unroll[(n)]
  <loops>
```

Parameters

(n)

(Optional) Specifies the number of iterations, `n`, to unroll. `n` must be an integer value. Without a value for `n`, the directive unrolls completely, and therefore is only applicable to a loop with a constant upperbound.

Example: Using unroll

Example usage of the `unroll` directive where the loop has an upperbound constant of 1000.

Code example:

```
subroutine add(a,b,c,d)
    integer, parameter :: m = 1000
    integer :: a(m), b(m), c(m), d(m)
    integer :: i
    !DIR$ UNROLL
    do i = 1, m
        b(i) = a(i) + 1
        d(i) = c(i) + 1
    end do
end subroutine add
```

The example uses the free-form syntax. For fixed-form formats, replace `!dir$` with `cdir$`.

Example: Using unroll to unroll with a specific number of unroll iterations

Example usage of the `unroll` directive where the loop has an upperbound constant of 1000, but is told to only unroll 5 iterations (`n` is 5).

Code example:

```
subroutine add(a,b,c,d)
  integer, parameter :: m = 1000
  integer :: a(m), b(m), c(m), d(m)
  integer :: i
  !dir$ unroll(5)
  do i =1, m
    b(i) = a(i) + 1
    d(i) = c(i) + 1
  end do
end subroutine add
```

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Note

The example uses the free-form syntax. For fixed-form formats, replace `!dir$` with `cdir$`.

Related information

nounroll on page 35
Optimization remarks on page 50
Arm Fortran Compiler Options by Function on page 58

4.1.5 nounroll

Prevents the compiler optimizer from unrolling a `DO` loop when optimization is enabled with an optimization level of `-O2`, `-O3`, or `-Ofast`.

Syntax

Command-line option:

None

Source:

```
!dir$ nounroll
  <loops>
```

Parameters

None

Example: Using nounroll

Example usage of the `nounroll` directive.

Code example:

```
subroutine add(a,b,c,d)
    integer, parameter :: m = 1000
    integer :: a(m), b(m), c(m), d(m)
    integer :: i
    !DIR$ NOUNROLL
    do i =1, m
        b(i) = a(i) + 1
        d(i) = c(i) + 1
    end do
end subroutine add
```

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Note

The example uses the free-form syntax. For fixed-form formats, replace `!dir$` with `cdir$`.

Related information

unroll on page 33
Optimization remarks on page 50
Arm Fortran Compiler Options by Function on page 58

4.1.6 vector always

Apply this directive to force vectorization of a loop. The directive tells the vectorizer to ignore any potential cost-based implications.


Note

The loop needs to be able to be vectorized.

Syntax

Command-line option:

None

Source:

```
!dir$ vector always
  <loops>
```

Parameters

None

Example: Using vector always

Example usage of the `vector always` directive.

Code example:

```
subroutine add(a,b,c,d,e,ub)
    implicit none
    integer :: i, ub
    integer, dimension(:) :: a, b, c, d, e
    !dir$ vector always
    do i=1, ub
        e(i) = a(c(i)) + b(d(i))
    end do
end subroutine add
```

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Note

The example uses the free-form syntax. For fixed-form formats, replace `!dir$` with `cdir$`.

Command-line invocation

```
armflang -c -O3 -fopenmp -Rpass-missed=loop-vectorize -Rpass=loop-vectorize -S
<file>.f90
```

The `-Rpass` and `-Rpass-missed` options enable optimization remarks about vectorized loops to be reported. To learn more about optimization remarks, see Optimization remarks.

Outputs

- With the pragma, the output for the example is:

```
remark: vectorized loop (vectorization width: 4, interleaved
count: 1) [-Rpass=loop-vectorize]
```

- Without the pragma, the output for the example is:

```
remark: the cost-model indicates that vectorization is not beneficial [-Rpass-
missed=loop-vectorize]
```

Related information

Optimization remarks on page 50

4.1.7 novector

Apply this directive to disable vectorization of a loop.


Note

Use this directive when vectorization would cause a performance regression, instead of a performance improvement.

Syntax

Command-line option:

None

Source:

```
!dir$ novector
  <loops>
```

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Parameters

None

Example: Using novector

Example usage of the `novector` directive.

Code example:

```
subroutine add(arr1,arr2,arr3,ub)
    integer :: arr1(ub), arr2(ub), arr3(ub)
    integer :: i
    !dir$ novector
    do i=1,ub
        arr1(i) = arr1(i) + arr2(i)
    end do
end subroutine add
```


Note

The example uses the free-form syntax. For fixed-form formats, replace `!dir$` with `cdir$`.

Command-line invocation

```
armflang -c -O2 -Rpass-missed=loop-vectorize -Rpass=loop-vectorize <file>.f90
```

The `-Rpass` and `-Rpass-missed` options enable optimization remarks about vectorized loops to be reported. To learn more about optimization remarks, see Optimization remarks.

Outputs

- With the pragma, the output for the example is:

  ```
  remark: loop not vectorized [-Rpass-missed=loop-vectorize]
  ```

- Without the pragma, the output for the example is:

  ```
  remark: vectorized loop (vectorization width: 4, interleaved count: 2)
  [-Rpass=loop-vectorize]
  ```

Related information

Optimization remarks on page 50

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4.2 Link Time Optimization (LTO)

This section describes what Link Time Optimization (LTO) is, when LTO is useful, and how to compile with LTO. The section also provides reference information about the `llvm-ar` and `llvm-ranlib` LLVM utilities that are required to compile static libraries with LTO.

4.2.1 What is Link Time Optimization (LTO)

Link Time Optimization is a form of interprocedural optimization that is performed at the time of linking application code. Without LTO, Arm® Compiler for Linux compiles and optimizes each source file independently of one another, then links them to form the executable. With LTO, Arm Compiler for Linux can process, consume, and use inter-module dependency information from across all the source files to enable further optimizations at link time. LTO is particularly useful when source files that have already been compiled separately.

The following describes the workflow that Arm Compiler for Linux takes with and without LTO enabled, in more detail:

- Without LTO:
  1. Source files are translated into separate ELF object files (`.o`) and passed to the linker.
  2. The linker processes the separate ELF object files, together with library code, to create the ELF executable.
- With LTO:
  1. Source files are translated into a bitcode object files (`.o`), and passed to the linker. LLVM Bitcode is an intermediate form of code that is understood by the optimizer.
  2. To extract the module dependency information, the linker processes the bitcode and object files together and passes them to the LLVM optimizer utility, libLTO.
  3. The LLVM optimizer utility, libLTO, uses the module dependency information to filter out unused modules, and create a single highly optimized ELF object file. Additional optimizations are possible by knowing the module dependency information. The new ELF object file is returned to the linker.
  4. The linker links the new ELF object file with the remaining ELF object files and library code, to generate an ELF executable.

Limitations

LTO in Arm Compiler for Linux has some limitations:

- To compile static libraries, you must create a library archive file that libLTO can use at link time. `armllvm-ar`, as well as some open-source utility tools can create this archive file. For more information about `armllvm-ar`, see armllvm-ar and reference.
- Partial linking is not supported with LTO because partial linking only works with ELF objects, rather than bitcode files.
- If your library code calls a function that was defined in the source code, but is removed by libLTO, you might get linking errors.

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- Bitcode objects are not guaranteed to be compatible across Arm Compiler for Linux versions. When linking with LTO, ensure that all your bitcode files are built using the same version of the compiler.
- You can not analyze LTO-optimized code using Arm Optimization Reports. Arm Optimization Reports analyzes object files that are generated by Arm Compiler for Linux before they are passed to the linker. Therefore, you can not use Arm Optimization Reports to investigate the vectorization decisions that LTO enables the linker to make.

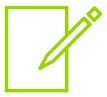
4.2.2 Compile with Link Time Optimization (LTO)

This topic describes how to compile your Fortran source code with Link Time Optimization (LTO), using Arm® Fortran Compiler.

Before you begin

- Download and install Arm Compiler for Linux. You can download Arm Compiler for Linux from the download page. Learn how to install and configure Arm Compiler for Linux, using the Arm Compiler for Linux installation instructions on the Arm Developer website.
- Load the environment module for Arm Compiler for Linux for your system.
- To compile your code with static libraries, you must create an archive of your libraries using an archive utility tool. Arm Compiler for Linux version 20.3+ includes variants of the LLVM archive utility tools `llvm-ar` (`armllvm-ar`) and `llvm-ranlib` (`armllvmran-lib`).

  If you use a Makefile to create the library archive and compile your application, open your Makefile and update any references of `llvm-ar` to `armllvm-ar`, and `llvm-ranlib` to `armllvm-ranlib`.



If you use `ar` to create your archives, you must also use the LLVM Gold Plugin to enable `ar` to use LLVM bitcode object files. For more information, see the LLVM gold plugin documentation.

For more information about `armllvm-ar`, see armllvm-ar and reference. For more information about `armllvm-ranlib`, see armllvm-ranlib reference.

Procedure

1. To generate an executable binary with LTO enabled, compile and link your code with `armflang`, and pass the `-flto` option:
   - For dynamic library compilation, use:

     ```
     armflang -O<level> -flto -o <binary> <sources>
     ```

   - For static library compilation:

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a. Compile, but do not link, your code with LTO:

```
armflang -O<level> -flto -c <sources>
```

The result is one or more `.o` files, one per source file that was passed to `armflang`.

b. Create the archive file for your static library object files:

```
armllvm-ar [config-options] [operation{modifiers)}] <archive> [<files>]
armllvm-ranlib <archive>
```

For example:

```
armllvm-ar rc example-archive.a source1.o source2.o
armllvm-ranlib example-archive.a
```

`armllvm-ar` builds a single archive file from one or more `.o` files. `r` is an operation that instructs `armllvm-ar` to replace existing archive files or, if they are new files, add the files to the end of the archive. `c` is a modifier to `r` that disables the warning which informs you that an archive has been created.

`armllvm-ranlib` builds an index for the `<archive>` file.

For a more detailed description of `armllvm-ar`, see armllvm-ar and reference. For a more detailed description of `armllvm-ar`, see armllvm-ranlib reference.

c. Link your remaining object files together with your archive file:

```
armflang -O<level> -flto -o <binary> <sources>.o <archive>
```

The `<archive>` file is used in place of the object files that where combined into the `<archive>` file by `armllvm-ar`.

---

2. (Optional) Use a tool like objdump to analyze the binary and view how the compiler optimized your code:

```
objdump -d <binary>
```

Results

Arm Fortran Compiler builds your LTO-optimized binary `<binary>`.

To run your binary, use:

```
./<binary>
```

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Example 4-1: Example: Compare code compiled with and without LTO

The following example application code is composed of two source files. `fortran-lto-main.f90` contains the `main` function which calls and a second function, `foo`, contained in `fortran-lto-foo.f90`. Compiling and analyzing example code without LTO enabled, then with LTO enabled, allows us to see the effect that LTO has on the application compilation.


Note

This example does not use static libraries.

1. Create the example source code files:
   a. Write and save the following code as a `fortran-lto-main.f90` source file:

```
PROGRAM main
   IMPLICIT NONE
   REAL, EXTERNAL :: foo
   INTEGER :: i, numelts, numargs
   CHARACTER(len=256) :: filename, elts, progname
   REAL, DIMENSION(:), ALLOCATABLE :: data
   numargs = command_argument_count()
   IF (numargs .NE. 2) THEN
      CALL get_command_argument(0, progname)
      WRITE(*,*) "Incorrect arguments."
      WRITE(*,*) "  Usage: " // &
                  progname(1:len_trim(progname)) // &
                  " <filename> <size>'"
      STOP
   END IF
   CALL get_command_argument(1, filename)
   CALL get_command_argument(2, elts)
   READ(elts, *) numelts
   ALLOCATE(data(numelts))
   OPEN(42, FILE=filename, STATUS='old', &
      ACCESS='stream', FORM='unformatted')
   READ(42) data
   DO i = 1, numelts
      data(i) = foo(data(i))
   END DO
   REWIND(42)
   WRITE(42) data
   CLOSE(42)
   DEALLOCATE(data)
END PROGRAM
```

   b. Write and save the following code as a `fortran-lto-foo.f90` source file:

```
REAL FUNCTION foo(val)
  foo = val*2.0
END FUNCTION
```

2. Use `armflang` to compile the code both without and with LTO enabled:
   a. To compile without LTO, into a binary called `binary-no-lto`, use:

```
armflang -O3 -o binary-no-lto fortran-lto-main.f90 fortran-lto-foo.f90
```

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b. To compile with LTO, into a binary called `binary-lto`, use:

```
armflang -O3 -flto -o binary-lto fortran-lto-main.f90 fortran-lto-foo.f90
```

3. To analyze the files to see the effect that LTO has on the generated code, use `objdump` to investigate the `main` function in the binary:

```
objdump -d binary-no-lto
```

In the following pseudo code:

- `{addr*}` represents an address. `{addr_main}`, `{addr_foo}`, and `{addr_loop_start}` are addresses that are given specific pseudo address names for the purpose of this example.
- {enc} represents the encoding.

For `binary-no-lto`, you can see separate functions `main` and `foo` in the following pseudo code:

```
{addr_main} <MAIN_>:
   ...
   {addr_loop_start}:    {enc}      add     x0, x8, x20
   {addr*}:              {enc}      bl      {addr_foo} <foo_>
   {addr*}:              {enc}      ldr     x8, [sp, #680]
   {addr*}:              {enc}      subs    x19, x19, #0x1
   {addr*}:              {enc}      str     s0, [x8, x20]
   {addr*}:              {enc}      add     x20, x20, #0x4
   {addr*}:              {enc}      b.ne    {addr_loop_start}
   ...
...
{addr_foo} <foo_>:
   {addr*}:       {enc}      ldr     s0, [x0]
   {addr*}:       {enc}      fadd    s0, s0, s0
   {addr*}:       {enc}      ret
```

`main` has a scalar loop with a branch to `foo` in it:

```
{addr*}:       {enc}        bl      {addr_foo} <foo_>
```

Whereas in `binary-lto`, you see one `main` function:

```
objdump -d binary-lto
```

Which gives:

```
{addr_main} <MAIN_>:
   ...
   {addr_loop_start}:     {enc}      ldr     q0, [x13], #16
   {addr*}:               {enc}      subs    x12, x12, #0x4
   {addr*}:               {enc}      fadd    v0.4s, v0.4s, v0.4s
   {addr*}:               {enc}      str     q0, [x14]
   {addr*}:               {enc}      mov     x14, x13
   {addr*}:               {enc}      b.ne    {addr_loop_start}
   ...
```

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In `main` in `binary-lto`, the simple `foo` function has been inlined and transformed into a vectorized loop: `fadd v0.4s, v0.4s, v0.4s`.

Related information

-flto on page 68
armllvm-ar and reference on page 44
armllvm-ranlib reference on page 45

4.2.3 armllvm-ar and reference

This topic describes `armllvm-ar`. `armllvm-ar` is a utility tool provided in the Arm® Compiler for Linux package, and is a variant of the LLVM `llvm-ar` utility tool.

`armllvm-ar` is an archiving tool that is similar to the Unix utility `ar`. However, unlike `ar`, `armllvm-ar` is able to understand the LLVM bitcode files that LLVM-based compilers produce when Link Time Optimization (LTO) is enabled.

`armllvm-ar` can archive several `.o` object (or bitcode object) files into a single archive library. As `armllvm-ar` archives the files, the tool creates a symbol table of the files. At link time, you can pass the archive to the compiler to link it into your application. When an archive is used by the compiler at link time, the symbol table enables linking to be performed faster than it would take the linker to link each file separately.


Note

For information about how `llvm-ar` differs from `ar`, see the llvm-ar LLVM command documentation.

Syntax

`armllvm-ar` can be run on the command line or through a Machine Readable Instruction (MRI) script. The following syntax is the command line syntax

```
armllvm-ar [config-options] [operation{modifiers)}] <archive> [<files>]
```


Note

`armllvm-ar` inherits the same syntax as `llvm-ar`.

Options for `armllvm-ar` are separated into *Configuration options*, *Operations*, and *Modifiers*:

- Configuration options are options that either configure how `llvm-ar` runs (for example how to set the default archive format), or are options to display help or version information.
- Operations are actions that are performed on an archive. You can only pass one operation to `armllvm-ar`.

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- Modifiers control how the operation completes the action. You can specify multiple modifiers to an operation, however, each operation supports different modifiers.

Options, Operations, and Modifiers

`armllvm-ar` supports the same options, operations, and modifiers that are supported by LLVM's `llvm-ar` tool. To see the options, operations, and modifiers that are supported by both utility tools, see the LLVM llvm-ar reference documentation.

Outputs

A successful run of `armllvm-ar` returns `0` and creates an archive called <archive>, which normally has a `.a` suffix. A nonzero return value indicates an error.

Related information

armllvm-ranlib reference on page 45

4.2.4 armllvm-ranlib reference

This topic describes `armllvm-ranlib`. `armllvm-ranlib` is a utility tool provided in the Arm® Compiler for Linux package, and is a variant of the LLVM `llvm-ranlib` utility tool.

Like, `llvm-ranlib` is a synonym to the LLVM archiver tool `llvm-ar -s`, `armllvm-ranlib` is a synonym for running `armllvm-ar -s`.


Note

For a full description of `llvm-ranlib` see the llvm-ranlib LLVM command documentation.

4.3 Arm Optimization Report

Arm Optimization Report builds on the llvm-opt-report tool available in open-source LLVM. Arm Optimization Report shows you the optimization decisions that the compiler is making, in-line with your source code, enabling you to better understand the unrolling, vectorization, and interleaving behavior.

Unrolling

Unrolling is when a scalar loop is transformed to perform multiple iterations at once, but still as scalar instructions.

The unroll factor is the number of iterations of the original loop that are performed at once. Sometimes, loops with known small iteration counts are completely unrolled, such that no loop structure remains. In completely unrolled cases, the unroll factor is the total scalar iteration count.

Vectorization

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Vectorization is when multiple iterations of a scalar loop are replaced by a single iteration of vector instructions.

The vectorization factor is the number of lanes in the vector unit, and corresponds to the number of scalar iterations that are performed by each vector instruction

---


Note

The true vectorization factor is unknown at compile-time for SVE, because SVE supports scalable vectors.

When SVE is enabled, Arm Optimization Report reports a vectorization factor that corresponds to a 128-bit SVE implementation.

If you are working with an SVE implementation with a larger vector width (for example, 256 bits or 512 bits), the number of scalar iterations that are performed by each vector instruction increases proportionally.

```
SVE scaling factor = <true SVE vector width> / 128
```

Loops vectorized using scalable vectors are annotated with `VS<F,I>`. For more information, see arm-opt-report reference.

Interleaving

Interleaving is a combination of vectorization followed by unrolling; multiple streams of vector instructions are performed in each iteration of the loop.

The combination of vectorization and unrolling information tells you how many iterations of the original scalar loop are performed in each iteration of the generated code.

```
Number of scalar iterations = <unroll factor> x <vectorization factor> x <interleave
 count> x <SVE scaling factor>
```


Note

The number of scalar iterations is not an exact figure. For SVE code, the compiler can use the predication capabilities of SVE. For example, a 10-iteration scalar operation on 64-bit values takes 3 iterations on a 256-bit SVE-enabled target.

Reference

The annotations that Arm Optimization Report uses to annotate source code, and the options that can be passed to `arm-opt-report`, are described in **arm-opt-report reference**.

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4.3.1 How to use Arm Optimization Report

This topic describes how to use Arm Optimization Report.

Before you begin

Download and install Arm® Compiler for Linux. For more information, see Download Arm Compiler for Linux and Installation.

Procedure

1. To generate a machine-readable `.opt.yaml` report, at compile time add `-fsave-optimization-record` to your command line.
   A `<filename>.opt.yaml` report is generated by Arm C/C++/Fortran Compiler, where `<filename>` is the name of the binary.
2. To inspect the `<filename>.opt.yaml` report, as augmented source code, use `arm-opt-report`:

   ```
   arm-opt-report <filename>.opt.yaml
   ```

   Annotated source code appears in the terminal.

Example 4-2: Example

1. Create an example file called `example.f90` containing the following code:

   ```
   subroutine foo
     implicit none
     call bar()
   end subroutine foo
   subroutine test
     implicit none
     integer :: i
     integer, dimension(1600) :: res, p, d
     do i = 1, 1600
       res(i) = merge(res(i), res(i) + d(i), p(i) == 0)
     end do
     do i = 1, 16
       res(i) = merge(res(i), res(i) + d(i), p(i) == 0)
     end do
     call foo()
     call foo()
     call bar()
     call foo()
   end subroutine test
   ```

2. Compile the file, for example to a shared object called `example.o`:

   ```
   armflang -O3 -fsave-optimization-record -c -o example.o example.f90
   ```

   This generates a file, `example.opt.yaml`, in the same directory as the built object.

   For compilations that create multiple object files, there is a report for each build object.

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Note

This example compiles to a shared object, however, you could also compile to a static object or to a binary.

3. View the `example.opt.yaml` file using `arm-opt-report`:

```
arm-opt-report example.opt.yaml
```

Annotated source code is displayed in the terminal:

```
< example.f90
 1           | subroutine foo
 2           |   implicit none
 3           |   call bar()
 4           | end subroutine foo
 5           |
 6           | subroutine test
 7           |   implicit none
 8           |   integer :: i
 9           |   integer, dimension(1600) :: res, p, d
10           |
11           |
12           |   do i = 1, 1600
13           |     res(i) = merge(res(i), res(i) + d(i), p(i) == 0)
14      V4,2 |   end do
15           |
16           |
17           |   do i = 1, 16
18           |     res(i) = merge(res(i), res(i) + d(i), p(i) == 0)
19   U16     |   end do
20           |
21 I         |   call foo()
22 I         |   call foo()
23           |   call bar()
24 I         |   call foo()
25           | end subroutine test
```

The example Arm Optimization Report output is interpreted as follows:

- The `do` loop on line 12:
  - Is vectorized
  - Has a vectorization factor of four (there are four 32-bit integer lanes)
  - Has an interleave factor of two (the loop was unrolled twice)
- The `for` loop on line 19 is unrolled 16 times. This means it is completely unrolled, with no remaining loops.
- All three instances of `call foo()` are inlined

Related information

arm-opt-report reference on page 49
Arm Compiler for Linux
Help and tutorials

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4.3.2 arm-opt-report reference

This reference topic describes the options that are available for `arm-opt-report`. The topic also describes the annotations that `arm-opt-report` can use to annotate source code.

`arm-opt-report` uses a YAML optimization record, as produced by the `-fsave-optimization-record` option of LLVM, to output annotated source code that shows the various optimization decisions taken by the compiler.

`-fsave-optimization-record` is not set by default by Arm® Compiler for Linux.

Possible annotations are:

Annotation	Description
`I`	A function was inlined.
`U<N>`	A loop was unrolled `<N>` times.
`V<F, I>`	A loop has been vectorized. Each vector iteration performed has the equivalent of `F*I` scalar iterations. Vectorization Factor, `F`, is the number of scalar elements that are processed in parallel. Interleave count, `I`, is the number of times the vector loop was unrolled.
`VS<F,I>`	A loop has been vectorized using scalable vectors. Each vector iteration performed has the equivalent of `N*F*I` scalar iterations, where `N` is the number of vector granules, which can vary according to the machine the application is run on. **Note:** LLVM assumes a granule size of 128 bits when targeting SVE. `F` (Vectorization Factor) and `I` (Interleave count) are as described for `V<F,I>`.

Syntax

```
arm-opt-report [options] <input>
```

Options

Generic Options:

`--help`

Displays the available options (use `--help-hidden` for more).

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--help-list
Displays a list of available options (`--help-list-hidden` for more).

--version
Displays the version information for `arm-opt-report`.

llvm-opt-report options:

--hide-detrimental-vectorization-info
Hides remarks about vectorization being forced despite the cost-model indicating that it is not beneficial.

--hide-inline-hints
Hides suggestions to inline function calls which are preventing vectorization.

--hide-lib-call-remark
Hides remarks about the calls to library functions that are preventing vectorization.

--hide-vectorization-cost-info
Hides remarks about the cost of loops that are not beneficial for vectorization.

--no-demangle
Does not demangle function names.

-o=<string>
Specifies an output file to write the report to.

-r=<string>
Specifies the root for relative input paths.

-s
Omits vectorization factors and associated information.

--strip-comments
Removes comments for brevity

--strip-comments=<arg>
Removes comments for brevity. Arguments are:

- `none`: Do not strip comments.
- `c`: Strip C-style comments.
- `c++`: Strip C++-style comments.
- `fortran`: Strip Fortran-style comments.

Outputs

Annotated source code.

Related information

How to use Arm Optimization Report on page 46

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4.4 Optimization remarks

Optimization remarks provide you with information about the choices that are made by the compiler. You can use them to see which code has been inlined or they can help you understand why a loop has not been vectorized.

By default, Arm® Compiler for Linux prints optimization remark information to `stderr`. If this is your terminal output, you might want to redirect the terminal output to a separate file to store and search the remark information more easily.

To enable optimization remarks, pass one or more of the following `-Rpass` options (in any order) to `armflang` at compile time:

- `-Rpass=<regex>`: Information about what the compiler has optimized.
- `-Rpass-analysis=<regex>`: Information about what the compiler has analyzed.
- `-Rpass-missed=<regex>`: Information about what the compiler failed to optimize.

For each option, replace `<regex>` with a remark expression that you want see. The supported remark types are:

- `loop-vectorize`: Provides remarks about vectorized loops.
- `inline`: Provides remarks about inlining.
- `loop-unroll`: Provides remarks about unrolled loops.

`<regex>` can be one or more of the preceding remark types. If you filter for multiple remark types, separate each type with a pipe (`|`) character.

For example, to request information about loops that were successfully vectorized, loops that the compiler failed to vectorize, and information about why a loop failed to vectorize, you can use:

```
armflang -O<level> -Rpass=loop-vectorize -Rpass-missed=loop-vectorize -Rpass-
analysis=loop-vectorize <source>.f90
```

Alternatively, you can choose to print all optimization remark information by specifying `.*` for `<regex>`, such as:

```
armflang -O<level> -Rpass=.* -Rpass-missed=.* -Rpass-analysis=.* <source>.f90
```

- Use `.*` with caution; depending on the size of code, and the level of optimization, the compiler can print a lot of information.
- Depending on your terminal, you might need to put the `<regex>` term inside single quotes, such as `'<regex>'`.

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It can also be useful to redirect the optimization remarks to a separate file. The general syntax to compile with optimization remarks enabled (`-Rpass[-<option>]`) and redirect the information to an output file (such as, `<remarks-file.txt>`), is:

```
armflang -O<level> -Rpass[-<option>]=<regex> <source>.f90 2> <remarks-file.txt>
```


Note

- `2> <remarks-file.txt>` assumes a Bourne-shell syntax. You need to replace this with the appropriate syntax to redirect output in your shell type.
- When you provide `-Rpass`, `armflang` generates debug line tables equivalent to passing `-gline-tables-only`, unless you instruct it not to. This default behavior ensures that the source location information is available to print the remarks.

4.4.1 Enable optimization remarks

Describes how to enable optimization remarks and redirect the information they provide to an output file.

Before you begin

Download and install Arm® Compiler for Linux. You can download Arm Compiler for Linux from the download page. Learn how to install and configure Arm Compiler for Linux, using the Arm Compiler for Linux installation instructions on the Arm Developer website.

Procedure

1. Compile your code with optimization remarks. To enable optimization remarks, pass one or more of `-Rpass=<regex>`, `-Rpass-missed=<regex>`, or `Rpass-analysis=<regex>` on your compile line.
   For example, to report all the remarks about vectorized loops (`-Rpass=loop-vectorize`), when compiling an input file called `source.f90`, use:

   ```
   armflang -O3 -Rpass=loop-vectorize source.f90 -gline-tables-only
   ```

   Result:

   ```
   example.f90:21: vectorized loop (vectorization width: 2,
   interleaved count: 1)
     [-Rpass=loop-vectorize]
       do i=1
   ```

2. Or, to print the optimization remark information to a separate file, instead of `stderr`, run:

   ```
   armflang -O<level> -Rpass[-<option>]=<remarks> <source> [<debug-option>] 2>
    <remarks-file>
   ```

   Replacing `2>` with the appropriate redirection syntax for the shell type

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For example, to redirect the output to a file called `vecreport.txt`, use:

```
armflang -O3 -Rpass=loop-vectorize -Rpass-analysis=loop-vectorize -Rpass-
missed=loop-vectorize source.F90 -gline-tables-only 2> vecreport.txt
```

Results

A `<remarks-file.txt>` file is created which contains the optimization remarks.

Related information

Arm Fortran Compiler

4.5 Profile Guided Optimization (PGO)

Learn about Profile Guided Optimization (PGO) and how to use `llvm-profdata`. `llvm-profdata` is LLVM's utility tool for profiling data and displaying profile counter and function information. `llvm-profdata` is included in Arm® Compiler for Linux.

Profile Guided Optimization (PGO) is a technique where you use profiling information to improve application run-time performance. To use PGO, you must generate profile information from an application, then recompile the application code while passing profile information to the compiler. The compiler can interpret and use the profile information to make informed optimization decisions. For example, when the compiler knows the frequency of a function call in an applications code, it can help the compiler make inlining decisions.

To enable the compiler to make the best optimization decisions for your applications code, you must pass profiling data that is representative of the applications typical workload. To generate profiling information that is representative of a typical workload, compile your application with your typical compiler options and run the application as you typically would.

The profile information can be generated from either:

- A sampling profiler
- An instrumented version of the code.

LLVM's documentation describes both methods. In this section, we only describe how to:

- Generate profile information from an instrumented version of the application code.
- Use `llvm-profdata` to combine and convert profile information from instrumented code into a format that the compiler can read as an input.

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4.5.1 How to compile with Profile Guided Optimization (PGO)

Learn how to use Profile Guided Optimization (PGO) with Arm® Fortran Compiler.

Before you begin

- Download and install Arm Compiler for Linux.
- Load the Arm Compiler for Linux environment module for your system.
- Add the `llvm-bin` directory to your `PATH`. For example:

```
PATH=$PATH:<install-dir>/../llvm-bin
```

Where `<install-dir>` is the Arm Compiler for Linux install location.

To obtain `<install-dir>` for your system, load the Arm Compiler for Linux environment module and run `which armflang`. The returned path is your `<install-dir>`.

About this task

The following procedure describes how to generate, and use, profile data using Arm Compiler for Linux. Profile data files generated by GCC compilers cannot be used by Arm Compiler for Linux.

Procedure

1. Build an instrumented version of your application code. Compile your application with the `-fprofile-generate` option:

```
armflang -O<level> [options] -fprofile-generate=<profile_dir> <source> -o
 <binary>
```

- When using PGO, Arm recommends using `-O2` optimization level, or higher.
- To ensure that the instrumented executable represents the real executable, compile your application code with the same compiler options.
- To specify the output location for the profile file, supply a directory name as an argument to `-fprofile-generate=`. If you do not specify a directory, `<profile_dir>`, the profile file is generated in the same directory as the source file.
- By default, the profile data file has the filename form `default-<id>.profraw`, where `<id>` is replaced with a unique identifier for the file. The next step in the procedure describes how to override the default filename behavior, if required.

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2. Run your application code with a typical workload. Either:
   - Run it with default behavior:

     ```
     ./<binary>
     ```

     The profile data file, `default-<id>.profraw`, is written to the directory location specified in the previous step, or if no directory was specified, to the same location as the source file.
   - Specify a new profile data filename using the `LLVM_PROFILE_FILE` environment variable, and run the application:

     ```
     LLVM_PROFILE_FILE=<profdata_file>.profraw ./<binary>
     ```

     Replace `"<profdata_file>.profraw"` with the filename, or file form, for your profile file. To define a filename form to ensure that repeat runs generate a unique profile file, use one or more of the following modifiers:
     - `%p` to state the process ID
     - `%h` to state the hostname
     - `%m` to state the unique profile name

     For example, `LLVM_PROFILE_FILE="example-{%p|%h|%m}.profraw"`.

     The profile data is written to `<profdata_file>.profraw`.
3. Combine and convert your `.profraw` files into a single processed `.profdata` file using the `llvm-profdata` tool `merge` command:
   - If you have a single `.profraw` file, use:

     ```
     llvm-profdata merge -output=<filename>.profdata <filename>.profraw
     ```

     
     Note

     Where you only have one `.profraw` file, no files are combined, however, you must still run the `merge` command to convert the file format to `.profdata`.
   - If you have multiple `.profraw` files, you can combine and convert them into a single `.profdata` profile data file. Navigate to the directory where your `.profraw` file (or files) is and either:
     - Pass each `.profraw` file in separately:

       ```
       llvm-profdata merge -output=<filename>.profdata <filename1>.profraw
        [<filename2>.profraw ...]
       ```
     - Pass in all of the `.profraw` files in that directory location:

       ```
       llvm-profdata merge -output=<filename>.profdata *.profraw
       ```

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4. Recompile your application code and pass the profile data file, `<filename>.profdata`, to `armflang` using the `-fprofile-use=<filename>.profdata` option:

```
armflang -O<level> -fprofile-use=<filename>.profdata <source> -o <binary>
```

   This step can be repeated without having to regenerate a new profile data file. However, as compilation decisions change and change the output application code, `armflang` might get to a point where the profile data can no longer be used. At this point, `armflang` outputs a warning.

Example 4-3: Example: Compiling code with PGO

This example uses 'foo.f90' as the source code file and 'foo-binary'.

1. Build an instrumented version of the `foo-binary` application code:

```
armflang -O2 -fprofile-generate foo.f90 -o foo-binary
```

2. Run `foo-binary` with a typical workload twice, creating separate `.profraw` files using their process ID to distinguish them:

```
LLVM_PROFILE_FILE="foorun-%p.profraw"
./foo-binary
./foo-binary
```

3. Combine and convert the `.profraw` files into a single processed `.profdata` file:

```
llvm-profdata merge -output=foorun.profdata foorun-*.profraw
```

4. Recompile the `foo-binary` application code passing the `foorun.profdata` profile data file to `armflang`:

```
armflang -O2 -fprofile-use=foorun.profdata foo.f90 -o foo-binary
```

Related information

llvm-profdata reference on page 56
LLVM's documentation
LLVM Command Guide

4.5.2 llvm-profdata reference

This topic describes the commands and lists the options for the `llvm-profdata` tool, for instrumentation-built profile data.

Full documentation for the `llvm-profdata` is available online in the LLVM Command Guide.

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In Arm® Compiler for Linux, the `llvm-profdata` tool is located in `<install_dir>/arm-linux-compiler-*/llvm-bin`. To enable the `llvm-profdata` tool, add the `llvm-bin` directory to your `PATH`.

`llvm-profdata` accepts three commands: `merge`, `show`, and `overlap`. The following table describes each.

Table 4-2: Describes the commands for `llvm-profdata`

Command	Syntax	Description	Common options
`merge`	`llvm-profdata merge -instr [options] [filename1] {[filename2] ...}`	`merge` combines multiple, instrumentation-built, profile data files into a single, indexed, profile data file.	• `-weighted-files=<weight>,<filename>` • `-input-files=<path>` • `-sparse=true|false` • `-num-threads=<value>` • `-prof-sym-list=<path>` • `-compress-all-sections=true|false`
`show`	`llvm-profdata show -instr [options] [filename]`	`show` displays profile counter and (optional) function information for a profile data file.	• `-all-functions` • `-counts` • `-function=<string>` • `-text` • `-topn=<value>` • `-memop-sizes` • `-list-below-cutoff` • `-showcs`
`overlap`	`llvm-profdata overlap [options] [base profile] [test profile]`	`overlap` displays the overlap of profile counter information for two profile data files or, optionally, for any functions that match a given string (`<string>`).	• `-function=<string>` • `-value-cutoff=<value>` • `-cs`

Global options that all of the commands accept include:

- `-help`
- `-output=<filename>`

Related information

LLVM Command Guide

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5 Compiler options

This chapter describes the options supported by `armflang`.

`armflang` provides many command-line options, including most Flang command-line options in addition to a number of Arm-specific options. Flang is a Fortran language front-end integrated with LLVM which, similar to Clang, supports community-supported options. Many common options, together with the Arm-specific options, are described in this chapter. The same options are also described in the tool through the `--help` option (run `armflang --help`), and in the `man` pages (run `man armflang`).

Additional information about community feature command-line options is available on the Flang community GitHub web site.

To see a list of arguments that Arm® Fortran Compiler supports for a specific option, bash terminal users can also use command line completion (also known as tab completion). For example, to list the supported arguments for `-ffp-contract=` with `armflang` type the following command line into your terminal (but do not run it):

```
armflang -ffp-contract=
```

Press the **Tab** button on your keyboard. The arguments supported by `-ffp-contract=` return:

```
fast  off  on
```

For more information about enabling this for other terminal types, see the installation instructions.

5.1 Arm Fortran Compiler Options by Function

This provides a summary of the `armflang` command-line options that Arm® Fortran Compiler supports.

Actions

Options that control what action to perform on the input.

Option	Description
-E	Stop after pre-processing. Output the pre-processed source.
-S	Stop after compiling the source and emit assembler files.
-c	Stop after compiling or assembling sources and do not link. This outputs object files.

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Option	Description
-fopenmp	Enable ('-fopenmp') or disable ('-fno-openmp' [default]) OpenMP and link in the OpenMP library, libomp.
-fsyntax-only	Show syntax errors but do not perform any compilation.

File options

Options that specify input or output files.

Option	Description
-I	Add a directory to include search path and Fortran module search path.
-J	Specifies a directory to place and to search for compiled module files.
-config	Passes the location of a configuration file to the compile command.
-isystem	Add a directory to the include search path, before system header file directories.
-o	Write the output to '<file>'.

Basic driver options

Options that affect basic functionality of the armclang or armflang driver.

Option	Description
-###	Print (but do not run) the commands to run for this compilation.
-gcc-toolchain=	Search for GCC installation in the specified directory on targets which commonly use GCC. The directory usually contains 'lib{,32,64}/gcc{,-cross}/$triple' and 'include'. If specified, sysroot is skipped for GCC detection. Note: executables (for example, 'ld') used by the compiler are not overridden by the selected GCC installation.
-help	Display available options.
-help-hidden	Display hidden options. Only use these options if advised to do so by your Arm representative.
-print-search-dirs	Print the paths that are used for finding libraries and programs.
-v	Show commands to run and use verbose output.
-version	Show the version number and some other basic information about the compiler.

Optimization options

Options that control what optimizations should be performed.

Option	Description
-O	Specifies the level of optimization to use when compiling source files.
-armpl=	Enable Arm Performance Libraries (ArmPL).
-fassociative-math	Allow ('-fassociative-math') or do not allow ('-fno-associative-math' [default]) the re-association of operands in a series of floating-point operations.

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Option	Description
-ffast-math	Enable ('-ffast-math') or disable ('-fno-fast-math' [default, except with '-Ofast']) aggressive, lossy floating-point optimizations.
-ffp-contract=	Controls when the compiler is permitted to generate fused floating-point operations (for example, Fused Multiply-Add (FMA) operations).
-finline-functions	Inline ('-finline-functions') or do not inline ('-fno-inline-functions') suitable functions.
-flto	Enable ('-flto') or disable ('-fno-lto' [default]) Link Time Optimizations (LTO).
-fsave-optimization-record	Enable ('-fsave-optimization-record') or disable ('-fno-save-optimization-record' [default]) the generation of a YAML optimization record file.
-fsigned-zeros	Allow ('-fno-signed-zeros') or do not allow ('-fsigned-zeros' [default, except with '-Ofast']) optimizations that ignore the sign of floating point zeros.
-fsimdmath	Enable ('-fsimdmath' [default for 'armflang']) or disable ('-fno-simdmath' [default for 'armclang|armclang++']) the vectorized libm library to support the vectorization of loops containing calls to basic library functions, such as those declared in math.h
-ftrapping-math	Tell the compiler to assume ('-ftrapping-math'), or not to assume ('-fno-trapping-math'), that floating point operations can trap. For example, divide by zero.
-fvectorize	Enable ('-fvectorize' [default]) or disable ('-fno-vectorize') loop vectorization.
-march=	Specifies the base architecture and extensions available on the target.
-mcpu=	Select which CPU architecture to optimize for.

Fortran Options

Options that affect the way Fortran workloads are compiled.

Option	Description
-fbackslash	Treat backslash as C-style escape character ('-fbackslash' [default]) or as a normal character ('-fno-backslash').
-fconvert=	Generate code suitable for a big- or little-endian system.
-ffixed-form	Force fixed-form format Fortran. This is default for .f and .F files, and is the inverse of -ffree-form.
-ffixed-line-length-	Set line length (0 | 72 | 132 | none) in fixed-form format Fortran. Default is 72. 0 and none are equivalent and set the line length to a very large value (>132).
-ffree-form	Force free-form format for Fortran. This is default for .f90 and .F90 files, and is the inverse of -ffixed-form.
-fnative-atomics	Enable ('-fnative-atomics' [default]) or disable ('-fno-native-atomics') the use of native atomic instructions for OpenMP atomics.
-fno-fortran-main	Do not link in Fortran main.
-frealloc-lhs	Select semantics for assignments to allocatables.

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Option	Description
-frecursive	Allocate all local arrays on the stack, allowing thread-safe recursion (enabled by default with -fopenmp).
-fstack-arrays	Place all automatic arrays on stack memory (enabled by default with -Ofast).
-i8	Treat INTEGER and LOGICAL as INTEGER*8 and LOGICAL*8.
-r8	Treat REAL as REAL*8.

Development options

Options that facilitate code development.

Option	Description
-g	Generate source-level debug information with DWARF version 4.
-g0	Disable the generation of source-level debug information.
-gline-tables-only	Emit debug line number tables only.

Warning options

Options that control the behavior of warnings.

Option	Description
-Qunused-arguments	Do not emit a warning for unused driver arguments.
-fno-crash-diagnostics	Disable the auto-generation of preprocessed source files and a script for reproduction during a clang crash.

Preprocessor options

Options that control the behavior of the preprocessor.

Option	Description
-D	Define a macro name to a value, '-D<macro>=<value>'. If a value is omitted, the macro is defined as 1.
-U	Undefine a macro, '-U<macro>'.
-cpp	Preprocess Fortran files.
-nocpp	Do not preprocess Fortran files.

Linker options

Options that are passed on to the linker or affect linking.

Option	Description
-L	Add a directory to the list of paths that the linker searches for user libraries.
-Wl,	Pass comma-separated arguments to the linker, '-Wl,<arg>,<arg>,...'.
-Xlinker	Pass an argument to the linker, '-Xlinker <arg>'.
-l	Search for a library when linking, '-l<library>'.
-shared	Create a shared object that can be linked against.

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Option	Description
-static	Link against static libraries.
-static-arm-libs	Link against static Arm libraries.

5.2 -###

Print (but do not run) the commands to run for this compilation.

Syntax

```
armflang -###
```

5.3 -armpl=

Enable Arm Performance Libraries (ArmPL).

Instructs the compiler to link with ArmPL. ArmPL provides functions optimized for a range of supported CPUs. The most suitable implementation is detected at runtime, not at compilation time, and it does not require any other compilation flags. This option also enables optimized versions of the C mathematical functions declared in the math.h library, tuned scalar and vector implementations of Fortran math intrinsics. This option implies `-fsimdmath`.

The -armpl option also enables:

- Optimized versions of the C mathematical functions declared in math.h.
- Optimized versions of Fortran math intrinsics.
- Auto-vectorization of C mathematical functions (disable this with `-fno-simdmath`).
- Auto-vectorization of Fortran math intrinsics (disable this with `-fno-simdmath`).

Default

By default, `-armpl` is not set (in other words, `OFF`)

Default argument behavior

If `-armpl` is set with no arguments, the default behavior of the option is `armpl=lp64,sequential`.

However, the default behavior of the arguments is also determined by the specification (or not) of the `-i8` (when using armflang) and `-fopenmp` options:

- If the `-i8` option is not specified, `lp64` is enabled by default. If `-i8` is specified, `ilp64` is enabled by default.
- If the `-fopenmp` option is not specified, `sequential` is enabled by default. If `-fopenmp` is specified, `parallel` is enabled by default.

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In other words:

- Specifying `-armpl` sets `-armpl=lp64,sequential`.
- Specifying `-armpl` and `-i8` sets `-armpl=ilp64,sequential`.
- Specifying `-armpl` and `-fopenmp` sets `-armpl=lp64,parallel`.
- Specifying `-armpl`, `-i8`, and `-fopenmp` sets `-armpl=ilp64,parallel`.

Syntax

```
armflang -armpl=<arg1>,<arg2>...
```

Arguments

`lp64`
Use 32-bit integers. (default)

`ilp64`
Use 64-bit integers. Inverse of lp64. (default if using `-i8` with armflang).

`sequential`
Use the single-threaded implementation of Arm Performance Libraries. (default)

`parallel`
Use the OpenMP multi-threaded implementation of Arm Performance Libraries. Inverse of sequential. (default if using `-fopenmp`)

5.4 -c

Stop after compiling or assembling sources and do not link. This outputs object files.

Syntax

```
armflang -c
```

5.5 -config

Passes the location of a configuration file to the compile command.

Use a configuration file to specify a set of compile options to be run at compile time. The configuration file can be passed at compile time, or an environment variable can be set for it to be used for every invocation of the compiler. For more information about creating and using a configuration file, see the installation instructions.

Syntax

```
armflang --config <arg>
```

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5.6 -cpp

Preprocess Fortran files.

Syntax

```
armflang -cpp
```

5.7 -D

Define a macro name to a value, '-D<macro>=<value>'. If a value is omitted, the macro is defined as 1.

Syntax

```
armflang -D<macro>=<value>
```

5.8 -E

Stop after pre-processing. Output the pre-processed source.

Syntax

```
armflang -E
```

5.9 -fassociative-math

Allow ('-fassociative-math') or do not allow ('-fno-associative-math' [default]) the re-association of operands in a series of floating-point operations.

For example, (a * b) + (a * c) => a * (b + c). Note: Using `-fassociative-math` violates the ISO C and C++ language standard.

Default

Default is `-fno-associative-math`.

Syntax

```
armflang -fassociative-math, -fno-associative-math
```

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5.10 -fbackslash

Treat backslash as C-style escape character ('-fbackslash' [default]) or as a normal character ('-fno-backslash').

Default

Default is the C-style, `-fbackslash`.

Syntax

```
armflang -fbackslash, -fno-backslash
```

5.11 -fconvert=

Generate code suitable for a big- or little-endian system.

Default

Default is `-fconvert=native`.

Syntax

```
armflang -fconvert={native \| swap \| big-endian \| little-endian}
```

Arguments

`native`
Automatically detect the endianness of the system that you are running the compiler on, and generate code suitable for the detected endianness. (Default)

`swap`
Automatically detect the endianness of the system that you are running the compiler on, and generate code suitable for the opposite endianness. For example, if the compiler detects a big-endian system, generate code for a little-endian system.

`big-endian`
Generate code suitable for a big-endian system.

`little-endian`
Generate code suitable for a little-endian system.

5.12 -ffast-math

Enable ('-ffast-math') or disable ('-fno-fast-math' [default, except with '-Ofast']) aggressive, lossy floating-point optimizations.

Using `-ffast-math` is equivalent to specifying the following options individually:

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- `-fassociative-math`
- `-ffinite-math-only`
- `-ffp-contract=fast`
- `-fno-math-errno`
- `-fno-signed-zeros`
- `-fno-trapping-math`
- `-freciprocal-math`

Default

Default is `-fno-fast-math`, except where `-Ofast` is used. Using `-Ofast` enables `-ffast-math`.

Syntax

```
armflang -ffast-math, -fno-fast-math
```

5.13 -ffixed-form

Force fixed-form format Fortran. This is default for .f and .F files, and is the inverse of -ffree-form.

Syntax

```
armflang -ffixed-form
```

5.14 -ffixed-line-length-

Set line length (0 | 72 | 132 | none) in fixed-form format Fortran. Default is 72. 0 and none are equivalent and set the line length to a very large value (>132).

Default

Default is `-ffixed-line-length-72`.

Syntax

```
armflang -ffixed-line-length-{0 \| 72 \| 132 \| none}
```

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5.15 -ffp-contract=

Controls when the compiler is permitted to generate fused floating-point operations (for example, Fused Multiply-Add (FMA) operations).

On the compile line, `-ffp-contract` supports three arguments to control the generation of fused floating-point operations: `OFF`, `ON`, and `FAST`. However, at the source level, you can also use the `STDC FP_CONTRACT={OFF|ON}` pragma to control the fused floating-point operation generation for C/C++ code:

- When `-ffp-contract` is set to `{off|on}`, `STDC FP_CONTRACT={OFF|ON}` is honored where it is specified, and can switch the generation.
- When `-ffp-contract` is set to `fast`, generation is always set to `FAST` and the `STDC FP_CONTRACT` pragma is ignored.

To produce better optimized code, allow the compiler to generate fused floating-point operations.

The fused floating-point instructions typically operate to a higher degree of accuracy than individual multiply and add instructions.

Default

For Fortran code, the default is `-ffp-contract=fast`. For C/C++ code, the default is `-ffp-contract=off`.

Syntax

```
armflang -ffp-contract={fast\|on\|off}
```

Arguments

`fast`

Generate fused floating-point operations whenever possible, even if the operations are not permitted by the language standard. Note: Some fused floating-point contractions are not permitted by the C/C++ standard because they can lead to deviations from the expected results.

`on`

Generate fused floating-point operations only when the language permits it. For example, for C/C++ code, floating-point contractions are permitted in a single C/C++ statement, however, for Fortran code, floating-point contractions are always permitted.

`off`

Do not generate fused floating-point operations.

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5.16 -ffree-form

Force free-form format for Fortran. This is default for .f90 and .F90 files, and is the inverse of -ffixed-form.

Syntax

```
armflang -ffree-form
```

5.17 -finline-functions

Inline ('-finline-functions') or do not inline ('-fno-inline-functions') suitable functions.

Note: For all `-finline-*` and `-fno-inline-*` options, the compiler ignores all but the last option that is passed to the compiler command.

Default

For `armclang|armclang++`, the default at `-O0` and `-O1` is `-fno-inline-functions`, and the default at `-O2` and higher is `-finline-functions`. For `armflang`, the default at all optimization levels is `-finline-functions`.

Syntax

```
armflang -finline-functions, -fno-inline-functions
```

5.18 -flto

Enable ('-flto') or disable ('-fno-lto' [default]) Link Time Optimizations (LTO).

You must pass the option to both the link and compile commands. When LTO is enabled, compiler object files contain an intermediate representation of the original code. When linking the objects together into a binary at link time, the compiler performs optimizations. It can allow the compiler to inline functions from different files, for example.

Default

Default is `-fno-lto`.

Syntax

```
armflang -flto, -fno-lto
```

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5.19 -fnative-atomics

Enable ('-fnative-atomics' [default]) or disable ('-fno-native-atomics') the use of native atomic instructions for OpenMP atomics.

By default, armflang generates native atomic instructions for OpenMP atomic operations, falling back to libatomic when no suitable native instruction is available. Use `-fno-native-atomics` to disable this feature and have armflang generate code that use barriers to guarantee atomicity. This will normally result in a slower program.

Default

Default is `-fnative-atomics`.

Syntax

```
armflang -fnative-atomics, -fno-native-atomics
```

5.20 -fno-crash-diagnostics

Disable the auto-generation of preprocessed source files and a script for reproduction during a clang crash.

Default

By default, `-fno-crash-diagnostics` is disabled. The default behavior of the compiler enables crash diagnostics.

Syntax

```
armflang -fno-crash-diagnostics
```

5.21 -fno-fortran-main

Do not link in Fortran main.

Syntax

```
armflang -fno-fortran-main
```

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5.22 -fopenmp

Enable ('-fopenmp') or disable ('-fno-openmp' [default]) OpenMP and link in the OpenMP library, libomp.

Default

Default is `-fno-openmp`.

Syntax

```
armflang -fopenmp, -fno-openmp
```

5.23 -frealloc-lhs

Select semantics for assignments to allocatables.

Fortran 2003 allows dynamic reallocation, which will error in Fortran 90/95. Use `-fno-realloc-lhs` to restore the F95 behavior. Default is F2003 semantics (`-frealloc-lhs`).

Default

Default is F2003 semantics (`-frealloc-lhs`).

Syntax

```
armflang -frealloc-lhs, -fno-realloc-lhs
```

5.24 -frecursive

Allocate all local arrays on the stack, allowing thread-safe recursion (enabled by default with -fopenmp).

In the absence of this flag, some large local arrays may be allocated in static memory. This reduces stack usage, but is not thread-safe.

Default

`-frecursive` is enabled by default with `-fopenmp`.

Syntax

```
armflang -frecursive
```

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5.25 -fsave-optimization-record

Enable ('-fsave-optimization-record') or disable ('-fno-save-optimization-record' [default]) the generation of a YAML optimization record file.

Optimization records are files named <output name>.opt.yaml, which can be parsed by arm-opt-report to show what optimization decisions the compiler is making, in-line with your source code. For more information, see the 'Optimize' chapter in the compiler developer and reference guide.

Default

Default is `fno-save-optimization-record`.

Syntax

```
armflang -fsave-optimization-record, -fno-save-optimization-record
```

5.26 -fsigned-zeros

Allow ('-fno-signed-zeros') or do not allow ('-fsigned-zeros' [default, except with '-Ofast']) optimizations that ignore the sign of floating point zeros.

Default

Default is `-fsigned-zeros`, except where `-Ofast` is used. Using `-Ofast` enables `-fno-signed-zeros`.

Syntax

```
armflang -fsigned-zeros, -fno-signed-zeros
```

5.27 -fsimdmath

Enable ('-fsimdmath' [default for 'armflang']) or disable ('-fno-simdmath' [default for 'armclang|armclang++']) the vectorized libm library to support the vectorization of loops containing calls to basic library functions, such as those declared in math.h

When vectorizing, `-fsimdmath` allows the compiler to generate calls to various vectorized library routines. These routines might use different algorithms to the scalar routine algorithms and their bit-reproducibility is not guaranteed. If you require your code to be bit reproducible, compile your code using the `-fno-simdmath` option.

Default

For `armclang|armclang++`, the default is `-fno-simdmath`. For `armflang`, the default is `-fsimdmath`.

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Syntax

```
armflang -fsimdmath, -fno-simdmath
```

5.28 -fstack-arrays

Place all automatic arrays on stack memory (enabled by default with -Ofast).

Use this option if your Fortran code frequently performs small allocations and deallocations of memory. `-fstack-arrays` improves application performance by using memory on the stack instead of allocating it through malloc, or similar. For programs using very large arrays on particular operating systems, consider extending stack memory runtime limits.

Syntax

```
armflang -fstack-arrays, -fno-stack-arrays
```

5.29 -fsyntax-only

Show syntax errors but do not perform any compilation.

Syntax

```
armflang -fsyntax-only
```

5.30 -ftrapping-math

Tell the compiler to assume ('-ftrapping-math'), or not to assume ('-fno-trapping-math'), that floating point operations can trap. For example, divide by zero.

Possible traps include:

- Division by zero
- Underflow
- Overflow
- Inexact result
- Invalid operation.

Default

Default is `-ftrapping-math`, except where `-Ofast` is used. Using `-Ofast` enables `-fno-trapping-math`.

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Syntax

```
armflang -ftrapping-math, -fno-trapping-math
```

5.31 -fvectorize

Enable ('-fvectorize' [default]) or disable ('-fno-vectorize') loop vectorization.

Default

Default is `-fno-vectorize`, except where `-O2`, `-O3`, or `-Ofast` are used. Using `-O2`, `-O3`, or `-Ofast` enables `-fvectorize`.

Syntax

```
armflang -fvectorize, -fno-vectorize
```

5.32 -g

Generate source-level debug information with DWARF version 4.

Default

Disabled by default.

Syntax

```
armflang -g
```

5.33 -g0

Disable the generation of source-level debug information.

Default

Enabled by default.

Syntax

```
armflang -g0
```

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5.34 -gcc-toolchain=

Search for GCC installation in the specified directory on targets which commonly use GCC. The directory usually contains 'lib{,32,64}/gcc{,-cross}/$triple' and 'include'. If specified, sysroot is skipped for GCC detection. Note: executables (for example, 'ld') used by the compiler are not overridden by the selected GCC installation.

Syntax

```
armflang --gcc-toolchain=<arg>
```

5.35 -gline-tables-only

Emit debug line number tables only.

Syntax

```
armflang -gline-tables-only
```

5.36 -help

Display available options.

Syntax

```
armflang -help, --help
```

5.37 -help-hidden

Display hidden options. Only use these options if advised to do so by your Arm representative.

Syntax

```
armflang --help-hidden
```

5.38 -I

Add a directory to include search path and Fortran module search path.

Directories specified with the `-I` option apply to both the quote form of the include directive and the system header form. For example, #include "file" (quote form), and #include <file> (system header form). Directories specified with `-I` are searched before system include directories and, in

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`armclang|armclang++` only, after directories specified with `-iquote` (for the quoted form). If any directory is specified with both `-I` and `-isystem` then the directory is searched for as if it were only specified with `-isystem`.

For `armflang`, search for module-files in the directories that are specified with the `-I` option. Directories that are specified with `-I` are searched after the current working directory and before standard system module locations.

Syntax

```
armflang -I<dir>
```

5.39 -i8

Treat INTEGER and LOGICAL as INTEGER*8 and LOGICAL*8.

Syntax

```
armflang -i8
```

5.40 -isystem

Add a directory to the include search path, before system header file directories.

Directories specified with the `-isystem` option apply to both the quote form of the include directive and the system header form. For example, #include "file" (quote form), and #include <file> (system header form). Directories specified with the `-isystem` option are searched after directories specified with `-I` and before system header file directories. Directories specified with `-isystem` are treated as system directories. If any directory is specified with both `-I` and `-isystem` then the directory is searched for as if it were only specified with `-isystem`.

Syntax

```
armflang -isystem<directory>
```

5.41 -J

Specifies a directory to place and to search for compiled module files.

The default location for compiled module files is the current directory. The specified directory is also added to the list of directories searched by a USE statement.

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Syntax

```
armflang -J<dir>
```

5.42 -L

Add a directory to the list of paths that the linker searches for user libraries.

Syntax

```
armflang -L<dir>
```

5.43 -l

Search for a library when linking, '-l<library>'.

Note: 'lib' is prepended to the supplied library name. For example, to search for 'libm', use `-lm`.

Syntax

```
armflang -l<library>
```

5.44 -march=

Specifies the base architecture and extensions available on the target.

Usage: `-march=<arg>` where `<arg>` is constructed as *name[+[no]feature+...]*:

name

`armv8-a` : Armv8 application architecture profile.

`armv8.1-a` : Armv8.1 application architecture profile.

`armv8.2-a` : Armv8.2 application architecture profile.

`armv8.3-a` : Armv8.3 application architecture profile.

`armv8.4-a` : Armv8.4 application architecture profile.

`armv8.5-a` : Armv8.5 application architecture profile.

`armv8.6-a` : Armv8.6 application architecture profile.

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feature

Is the name of an optional architectural feature that can be explicitly enabled with +feature and disabled with +nofeature.

For AArch64, the following features can be specified:

- `crc` - Enable CRC extension. On by default for `-march=armv8.1-a` or higher.
- `crypto` - Enable Cryptographic extension.
- `fullfp16` - Enable FP16 extension.
- `lse` - Enable Large System Extension instructions. On by default for `-march=armv8.1-a` or higher.
- `sve` - Scalable Vector Extension (SVE). This feature also enables `fullfp16`. See Scalable Vector Extension for more information.
- `sve2`- Scalable Vector Extension version two (SVE2). This feature also enables `sve`. See Arm A64 Instruction Set Architecture for SVE and SVE2 instructions.
- `sve2-aes` - SVE2 Cryptographic extension. This feature also enables `sve2`.
- `sve2-bitperm` - SVE2 Cryptographic Extension. This feature also enables `sve2`.
- `sve2-sha3` - SVE2 Cryptographic Extension. This feature also enables `sve2`.
- `sve2-sm4` - SVE2 Cryptographic Extension. This feature also enables `sve2`.

Syntax

```
armflang -march=<arg>
```

5.45 -mcpu=

Select which CPU architecture to optimize for.

Syntax

```
armflang -mcpu=<arg>
```

Arguments

`native`

Auto-detect the CPU architecture from the build computer.

`thunderx2t99`

Optimize for Marvell ThunderX2 based computers.

`neoverse-n1`

Optimize for Neoverse N1 based computers.

`neoverse-n2`

Optimize for Neoverse N2 based computers.

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neoverse-v1
Optimize for Neoverse V1 based computers.

a64fx
Optimize for Fujitsu A64FX based computers.

generic
Generate portable code suitable for any Armv8-A based computer.

5.46 -nocpp

Do not preprocess Fortran files.

Syntax

```
armflang -nocpp
```

5.47 -O

Specifies the level of optimization to use when compiling source files.

Note: If you use `-O2`, `-O3`, or `-Ofast` with the `-fsimdmath` option, the compiler might vectorize loops using calls to vectorized math routines, affecting the bit reproducibility. For more information, see the `-fsimdmath` option description.

Default

The default is `-O0`. However, for the best balance between ease of debugging, code size, and performance, it is important to choose an optimization level that is appropriate for your goals.

Syntax

```
armflang -O<level>
```

Arguments

0
Minimum optimization for the performance of the compiled binary. Turns off most optimizations. When debugging is enabled, this option generates code that directly corresponds to the source code. Therefore, this might result in a significantly larger image. This is the default optimization level.

1
Restricted optimization. When debugging is enabled, this option gives the best debug view for the trade-off between image size, performance, and debug.

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2

High optimization. When debugging is enabled, the debug view might be less satisfactory because the mapping of object code to source code is not always clear. The compiler might perform optimizations that cannot be described by debug information.

3

Very high optimization. When debugging is enabled, this option typically gives a poor debug view. Arm recommends debugging at lower optimization levels.

fast

Enables all the optimizations from level 3 including those performed with the `-ffp-mode=fast` option. This level also performs other aggressive optimizations that might violate strict compliance with language standards. `-Ofast` implies `-ffast-math`.

5.48 -o

Write the output to '<file>'.

Default

If a user-defined filename is not provided, the compiler uses the input filename as the output filename (replacing the extension, as appropriate). If a user-defined filename is provided, the compiler writes the output to the provided filename.

Syntax

```
armflang -o<file>
```

5.49 -print-search-dirs

Print the paths that are used for finding libraries and programs.

Syntax

```
armflang -print-search-dirs, --print-search-dirs
```

5.50 -Qunused-arguments

Do not emit a warning for unused driver arguments.

Syntax

```
armflang -Qunused-arguments
```

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5.51 -r8

Treat REAL as REAL*8.

Syntax

```
armflang -r8
```

5.52 -S

Stop after compiling the source and emit assembler files.

Syntax

```
armflang -S
```

5.53 -shared

Create a shared object that can be linked against.

Syntax

```
armflang -shared, --shared
```

5.54 -static

Link against static libraries.

This option prevents runtime dependencies on shared libraries. This is likely to result in larger binaries.

Syntax

```
armflang -static, --static
```

5.55 -static-arm-libs

Link against static Arm libraries.

This option prevents runtime dependencies on libraries shipped with Arm Compiler for Linux (such as libamath, libastring and Arm Performance Libraries). This is likely to result in larger binaries.

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Syntax

```
armflang -static-arm-libs
```

5.56 -U

Undefine a macro, '-U<macro>'.

Syntax

```
armflang -U<macro>
```

5.57 -v

Show commands to run and use verbose output.

Syntax

```
armflang -v
```

5.58 -version

Show the version number and some other basic information about the compiler.

Syntax

```
armflang --version, --vsn
```

5.59 -Wl,

Pass comma-separated arguments to the linker, '-Wl,<arg>,<arg>,...'.

Syntax

```
armflang -Wl,<arg>,<arg2>...
```

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5.60 -Xlinker

Pass an argument to the linker, '-Xlinker <arg>'.

Syntax

```
armflang -Xlinker <arg>
```

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6 Fortran language reference

This chapter can be used as a reference for the Fortran 90, Fortran 95, Fortran 2003, Fortran 2008, and Fortran 2018 language features that are supported by Arm® Fortran Compiler.

The support level for the latest Fortran standards (2003 and 2008) are described in Standards support.

For information about the Fortran standards, see the JTC1/SC22/WG5 Fortran standards website.

6.1 Data types and file extensions

Describes the data types and file extensions that are supported by the Arm® Fortran Compiler.

6.1.1 Data types

Arm® Fortran Compiler provides the following intrinsic data types:

Table 6-1: Intrinsic data types

Data Type	Specified as	Size (bytes)
INTEGER	INTEGER	4
	INTEGER*1	1
	INTEGER([KIND=]1)	1
	INTEGER*2	2
	INTEGER([KIND=]2)	2
	INTEGER*4	4
	INTEGER([KIND=]4)	4
	INTEGER*8	8
	INTEGER([KIND=]8)	8
REAL	REAL	4
	REAL*4	4
	REAL([KIND=]4)	4
	REAL*8	8
	REAL([KIND=]8)	8

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Data Type	Specified as	Size (bytes)
DOUBLE PRECISION	DOUBLE PRECISION (same as REAL*8, no KIND parameter is permitted)	16
COMPLEX	COMPLEX	4
	COMPLEX*8	8
	COMPLEX([KIND=]4)	8
	COMPLEX*16	16
	COMPLEX([KIND=]8)	16
DOUBLE COMPLEX	DOUBLE COMPLEX (same as COMPLEX*8, no KIND parameter is permitted)	8
LOGICAL	LOGICAL	4
	LOGICAL*1	1
	LOGICAL([KIND=]1)	1
	LOGICAL*2	2
	LOGICAL([KIND=]2)	2
	LOGICAL*4	4
	LOGICAL([KIND=]4)	4
	LOGICAL*8	8
	LOGICAL([KIND=]8)	8
CHARACTER	CHARACTER	1
	CHARACTER([KIND=]1)	1
BYTE	BYTE (same as INTEGER([KIND=]1))	1


Note

- The default entries are the first entries for each intrinsic data type.
- To determine the kind type parameter of a representation method, use the intrinsic function `KIND`.

For more portable programs, define a `PARAMETER` constant using the appropriate `SELECTED_INT_KIND` or `SELECTED_REAL_KIND` functions, as appropriate.

For example, this code defines a `PARAMETER` constant for an `INTEGER` kind. The kind has the value of a real data type, with the decimal precision of at least 6 digits and an exponent range of at least 17 digits (single precision):

```
INTEGER, PARAMETER :: my_real_kind = SELECTED_REAL_KIND(6, 17)
...
REAL(my_real_kind) :: x
```

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```
...
```

Or, alternatively, use the `ISO_FORTRAN_ENV` intrinsic module, which then makes the `REAL32` and `REAL64` kind parameters available to use. For example:

```
USE ISO_FORTRAN_ENV
INTEGER, PARAMETER :: my_real_kind = REAL32
...
REAL(my_real_kind) :: x
...
```

6.1.2 Supported file extensions

The extensions `f90`, `.f95`, `.f03`, and `.f08` are used for modern, free-form source code conforming to the Fortran 90, Fortran 95, Fortran 2003, and Fortran 2008 standards, respectively.

The extensions `.F90`, `.F95`, `.F03`, and `.F08` are used for modern, free-form source code that require preprocessing, and conform to the Fortran 90, Fortran 95, Fortran 2003, and Fortran 2008 standards, respectively.

The `.f` and `.for` extensions are typically used for older, fixed-form code such as FORTRAN77.

The file extensions that are compatible with Arm® Fortran Compiler are:

Table 6-2: Supported file extensions

File Extension	Interpretation
a.out	Executable output file.
file.a	Library of object files.
file.f file.for	Fixed-format Fortran source file.
file.fpp file.F	Fixed-format Fortran source file that requires preprocessing.
file.f90 file.f95 file.f03 file.f08	Free-format Fortran source file.
file.F90 file.F95 file.F03 file.F08	Free-format Fortran source file that requires preprocessing.
file.o	Compiled object file.

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File Extension	Interpretation
file.s	Assembler source file.

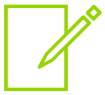
6.1.3 Logical variables and constants

This topic describes `LOGICAL` variables and constants.

A `LOGICAL` constant is either `True` or `False`. The Fortran standard does not specify how variables of `LOGICAL` type are represented. However, it does require `LOGICAL` variables of default kind to have the same storage size as default `INTEGER` and `REAL` variables.

For Arm® Fortran Compiler:

- `.TRUE.` corresponds to -1 and has a default storage size of 4-bytes.
- `.FALSE.` corresponds to 0 and has a default storage size of 4-bytes.


Note

Some compilers represent `.TRUE.` and `.FALSE.` as 1 and 0, respectively.

6.1.4 C/Fortran inter-language calling

This section provides some useful troubleshooting information when handling argument passing and return values for Fortran functions or subroutines that are called from C/C++ code.

In Fortran, arguments are passed by reference. Here, reference means the address of the argument is passed, rather than the argument itself. In C/C++, arguments are passed by value, except for strings and arrays, which are passed by reference.

C/C++ provides some flexibility when solving passing difference with Fortran. Usually, intelligent use of the & and * operators in argument passing enables you to call Fortran from C/C++, and in argument declarations when Fortran is calling C/C++.

Fortran functions which return `CHARACTER` or `COMPLEX` data types require special consideration when called from C/C++ code.

6.1.5 Character

This topic describes how C/C++ functions call Fortran functions that return a `CHARACTER`.

Fortran functions that return a `CHARACTER` require the *calling* C/C++ function to have two arguments to describe the result:

1. The first argument provides the address of the returned character.

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2. The second argument provides the length of the returned character.

For example, the Fortran function:

```
CHARACTER*(*) FUNCTION CHF( C1, I)
     CHARACTER*(*) C1
     INTEGER I
END
```

when called in C/C++, has an extra declaration:

```
extern void chf_();
     char tmp[10];
     char c1[9];
     int i;
     chf_(tmp, 10, c1, &i, 9);
```

The argument, `tmp`, provides the address, and the length is defined with the second argument, `10`.

- Fortran functions declared with a character return length, for example `CHARACTER*4 FUNCTION CHF()`, still require the second parameter to be supplied to the calling C/C++ code.
- The value of the character function is not automatically NULL-terminated.

6.1.6 Complex

This topic describes how to call Fortran functions that return a `COMPLEX` data type, from C or C++.

Fortran functions that return a `COMPLEX` data type cannot be directly called from C or C++. Instead, a workaround is possible by passing a C or C++ function a pointer to a memory area. This memory area can then be calling the `COMPLEX` function and storing the returned value.

For example, the Fortran function:

```
SUBROUTINE INTER_CF(C, I)
  COMPLEX C
  COMPLEX CF
  C = CF(I)
  RETURN
END
COMPLEX FUNCTION CF(I)
  . . .
END
```

when called in C/C++ is completed using a memory pointer:

```
extern void inter_cf_();
    typedef struct {float real, imag;} cplx;
    cplx c1;
    int i;
```

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```
    inter_cf_( &c1, &i);
```

6.1.7 Fortran implementation notes

Details information that is specific to the implementation of Fortran in Arm® Fortran Compiler.

Implementation information:

- Arm Fortran Compiler does not initialize arrays or variables with zeros.

This behavior varies from compiler to compiler and is not defined in Fortran standards. The best practice is not to assume that arrays are filled with zeros when they are created.

6.2 Intrinsics

The Fortran language standards that are implemented in Arm® Fortran Compiler are Fortran 77, Fortran 90, Fortran 95, Fortran 2003, and Fortran 2008. This topic details the supported and unsupported Fortran intrinsics in Arm Fortran Compiler.

6.2.1 Fortran intrinsics overview

An intrinsic is a function made available for a given language standard, for example, Fortran 95. Intrinsic functions accept arguments and return values. When an intrinsic function is called in the source code, the compiler replaces the function with a set of automatically generated instructions. It is best practice to use these intrinsics to enable the compiler to optimize the code most efficiently.

The intrinsics listed in the following tables are specific to Fortran 90/95, unless explicitly stated.

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6.2.2 Bit manipulation functions and subroutines

Functions and subroutines for manipulating bits.

Table 6-3: Bit manipulation functions and subroutines

Intrinsic	Description	Num. of Arguments	Argument Type	Result
AND	Perform a logical AND on corresponding bits of the arguments.	2	Any, except CHAR or COMPLEX	INTEGER or LOGICAL
BIT_SIZE	Return the number of bits (the precision) of the integer argument.	1	INTEGER	INTEGER
BTEST	Test the binary value of a bit in a specified position of an integer argument.	2	INTEGER, INTEGER	LOGICAL
IAND	Perform a bit-by-bit logical AND on the arguments.	2	INTEGER, INTEGER (of same kind)	INTEGER
IBCLR	Clear one bit to zero.	2	INTEGER, INTEGER >=0	INTEGER
IBITS	Extract a sequence of bits.	3	INTEGER, INTEGER >=0, INTEGER >=0	INTEGER
IBSET	Set one bit to one.	2	INTEGER, INTEGER >=0	INTEGER
IEOR	Perform a bit-by-bit logical exclusive OR on the arguments.	2	INTEGER, INTEGER (of same kind)	INTEGER
IOR	Perform a bit-by-bit logical OR on the arguments.	2	INTEGER, INTEGER (of same kind)	INTEGER
ISHFT	Perform a logical shift.	2	INTEGER, INTEGER	INTEGER
ISHFTC	Perform a circular shift of the rightmost bits.	2 or 3	INTEGER, INTEGER or INTEGER, INTEGER, INTEGER	INTEGER
LSHIFT	Perform a logical shift to the left.	2	INTEGER, INTEGER	INTEGER
MVBITS	Copy bit sequence.	5	INTEGER(IN), INTEGER(IN), INTEGER(IN), INTEGER(IN, OUT), INTEGER(IN)	N/A
NOT	Perform a bit-by-bit logical complement on the argument.	2	INTEGER	INTEGER
OR	Perform a logical OR on each bit of the arguments.	2	Any except CHAR or COMPLEX	INTEGER or LOGICAL
POPCNT	Return the number of one bits. (F2008)	1	INTEGER or bits	INTEGER
POPPAR	Return the bitwise parity. (F2008)	1	INTEGER or bits	INTEGER
RSHIFT	Perform a logical shift to the right.	2	INTEGER, INTEGER	INTEGER
SHIFT	Perform a logical shift.	2	Any except CHAR or COMPLEX, INTEGER	INTEGER or LOGICAL

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Intrinsic	Description	Num. of Arguments	Argument Type	Result
XOR	Perform a logical exclusive OR on each bit of the arguments.	2	INTEGER, INTEGER	INTEGER
ZEXT	Zero-extend the argument.	1	INTEGER or LOGICAL	INTEGER

6.2.3 Elemental character and logical functions

Elemental character logical conversion functions.

Table 6-4: Elemental character and logical functions

Intrinsic	Description	Num. of Arguments	Argument Type	Result
ACHAR	Return character in specified ASCII collating position.	1	INTEGER	CHARACTER
ADJUSTL	Left adjust string.	1	CHARACTER	CHARACTER
ADJUSTR	Right adjust string.	1	CHARACTER	CHARACTER
CHAR	Return character with specified ASCII value.	1	LOGICAL*1 INTEGER	CHARACTER CHARACTER
IACHAR	Return position of character in ASCII collating sequence.	1	CHARACTER	INTEGER
ICHAR	Return position of character in the character set's collating sequence.	1	CHARACTER	INTEGER
INDEX	Return starting position of substring in first string.	2 3	CHARACTER, CHARACTER CHARACTER, CHARACTER, LOGICAL	INTEGER INTEGER
LEN	Return the length of string.	1	CHARACTER	INTEGER
LEN_TRIM	Return the length of the supplied string minus the number of trailing blanks.	1	CHARACTER	INTEGER
LGE	Test the supplied strings to determine if the first string is lexically greater than or equal to the second. **Note:** From F2008, character kind ASCII is also supported.	2	CHARACTER, CHARACTER	LOGICAL

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Intrinsic	Description	Num. of Arguments	Argument Type	Result
LGT	Test the supplied strings to determine if the first string is lexically greater than the second. **Note:** From F2008, character kind ASCII is also supported.	2	CHARACTER, CHARACTER	LOGICAL
LLE	Test the supplied strings to determine if the first string is lexically less than or equal to the second. **Note:** From F2008, character kind ASCII is also supported.	2	CHARACTER, CHARACTER	LOGICAL
LLT	Test the supplied strings to determine if the first string is lexically less than the second. **Note:** From F2008, character kind ASCII is also supported.	2	CHARACTER, CHARACTER	LOGICAL
LOGICAL	Logical conversion.	1 2	LOGICAL LOGICAL, INTEGER	LOGICAL LOGICAL
SCAN	Scan string for characters in set.	2 3	CHARACTER, CHARACTER CHARACTER, CHARACTER, LOGICAL	INTEGER INTEGER
VERIFY	Determine if string contains all characters in set.	2 3	CHARACTER, CHARACTER CHARACTER, CHARACTER, LOGICAL	INTEGER INTEGER

6.2.4 Vector/Matrix functions

Functions for vector or matrix multiplication.

Table 6-5: Vector and matrix functions

Intrinsic	Description	Num. of Arguments	Argument Type	Result
DOT_PRODUCT	Perform dot product on two vectors.	2	INTEGER, REAL, COMPLEX, or LOGICAL	INTEGER, REAL, COMPLEX, or LOGICAL
MATMUL	Perform matrix multiply on two matrices.	2	INTEGER, REAL, COMPLEX, or LOGICAL	INTEGER, REAL, COMPLEX, or LOGICAL

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All matrix outputs are the same type as the argument supplied.

6.2.5 Array reduction functions

Functions for determining information from, or calculating using, the elements in an array.

Table 6-6: Array reduction functions

Intrinsic	Description	Num. of Arguments	Argument Type	Result
`ALL`	Determine if all array values are true.	1	LOGICAL	LOGICAL
		2	LOGICAL, INTEGER	LOGICAL
`ANY`	Determine if any array value is true.	1	LOGICAL	LOGICAL
		2	LOGICAL, INTEGER	LOGICAL
`COUNT`	Count true values in array.	1	LOGICAL	INTEGER
		2	LOGICAL, INTEGER	INTEGER
`MAXLOC`	Determine the position of the array element with the maximum value.	1	INTEGER	INTEGER
		2	INTEGER, LOGICAL	INTEGER
		2	INTEGER, INTEGER	INTEGER
		3	INTEGER, INTEGER, LOGICAL	INTEGER
		1	REAL	REAL
		2	REAL, LOGICAL	REAL
		2	REAL, INTEGER	REAL
		3	REAL, INTEGER, LOGICAL	REAL

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Intrinsic	Description	Num. of Arguments	Argument Type	Result
MAXVAL	Determine the maximum value of the array elements.	1	INTEGER	INTEGER
		2	INTEGER, LOGICAL	INTEGER
		2	INTEGER, INTEGER	INTEGER
		3	INTEGER, INTEGER, LOGICAL	INTEGER
		1	REAL	REAL
		2	REAL, LOGICAL	REAL
		2	REAL, INTEGER	REAL
		3	REAL, INTEGER, LOGICAL	REAL
MINLOC	Determine the position of the array element with the minimum value.	1	INTEGER	INTEGER
		2	INTEGER, LOGICAL	INTEGER
		2	INTEGER, INTEGER	INTEGER
		3	INTEGER, INTEGER, LOGICAL	INTEGER
		1	REAL	REAL
		2	REAL, LOGICAL	REAL
		2	REAL, INTEGER	REAL
		3	REAL, INTEGER, LOGICAL	REAL
MINVAL	Determine the minimum value of the array elements.	1	INTEGER	INTEGER
		2	INTEGER, LOGICAL	INTEGER
		2	INTEGER, INTEGER	INTEGER
		3	INTEGER, INTEGER, LOGICAL	INTEGER
		1	REAL	REAL
		2	REAL, LOGICAL	REAL
		2	REAL, INTEGER	REAL
		3	REAL, INTEGER, LOGICAL	REAL

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Intrinsic	Description	Num. of Arguments	Argument Type	Result
PRODUCT	Calculate the product of the elements of an array.	1	NUMERIC	NUMERIC
		2	NUMERIC, LOGICAL	NUMERIC
		2	NUMERIC, INTEGER	NUMERIC
		3	NUMERIC, INTEGER, LOGICAL	NUMERIC
SUM	Calculate the sum of the elements of an array.	1	NUMERIC	NUMERIC
		2	NUMERIC, LOGICAL	NUMERIC
		2	NUMERIC, INTEGER	NUMERIC
		3	NUMERIC, INTEGER, LOGICAL	NUMERIC

6.2.6 String construction functions

Functions for constructing strings.

Table 6-7: String construction functions

Intrinsic	Description	Num. of Arguments	Argument Type	Result
REPEAT	Concatenate copies of a string.	2	CHARACTER, INTEGER	CHARACTER
TRIM	Remove trailing blanks from a string.	1	CHARACTER	CHARACTER

6.2.7 Array construction manipulation functions

Functions for constructing and manipulating arrays.

Table 6-8: Array construction and manipulation functions

Intrinsic	Description	Num. of Arguments	Argument Type	Result
CSHIFT	Perform circular shift on an array.	2	ARRAY, INTEGER	ARRAY
		3	ARRAY, INTEGER, INTEGER	ARRAY
OESHIFT	Perform end-off shift on an array.	2	ARRAY, INTEGER	ARRAY
		3	ARRAY, INTEGER, Any	ARRAY
		3	ARRAY, INTEGER, INTEGER	ARRAY
		4	ARRAY, INTEGER, Any, INTEGER	ARRAY, ARRAY

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Intrinsic	Description	Num. of Arguments	Argument Type	Result
MERGE	Merge two arguments using the logical mask.	3	Any, Any, LOGICAL The second argument must be of the same type as the first argument.	Any
PACK	Pack an array into a rank-one array.	2 3	ARRAY, LOGICAL ARRAY, LOGICAL, VECTOR	ARRAY ARRAY
RESHAPE	Change the shape of an array.	2 3 3 4	ARRAY, INTEGER ARRAY, INTEGER, ARRAY ARRAY, INTEGER, INTEGER ARRAY, INTEGER, ARRAY, INTEGER	ARRAY ARRAY ARRAY ARRAY
SPREAD	Replicate an array by adding a dimension.	3	Any, INTEGER, INTEGER	ARRAY
TRANSPOSE	Transpose an array of rank two.	1	ARRAY (m, n)	ARRAY (n, m)
UNPACK	Unpack a rank-one array into an array of multiple dimensions.	3	VECTOR, LOGICAL, ARRAY	ARRAY


Note

All ARRAY outputs are the same type as the argument supplied.

6.2.8 General inquiry functions

Functions for general determining.

Table 6-9: General inquiry functions

Intrinsic	Description	Num. of Arguments	Argument Type	Result
ASSOCIATED	Determine association status.	1 2	POINTER, POINTER, ..., POINTER, TARGET	LOGICAL LOGICAL
KIND	Determine the kind of an argument.	1	Any intrinsic type	INTEGER
PRESENT	Determine presence of optional argument.	1	Any	LOGICAL

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6.2.9 Numeric inquiry functions

Functions for determining numeric information.

Table 6-10: Numeric inquiry functions

Intrinsic	Description	Num. of Arguments	Argument Type	Result
`DIGITS`	Determine the number of significant digits.	1 1	INTEGER REAL	INTEGER
`EPSILON`	Smallest number that can be represented.	1	REAL	REAL
`HUGE`	Largest number that can be represented.	1 1	INTEGER REAL	INTEGER REAL
`MAXEXPONENT`	Value of the maximum exponent.	1	REAL	INTEGER
`MINEXPONENT`	Value of the minimum exponent.	1	REAL	INTEGER
`PRECISION`	Decimal precision.	1 1	REAL COMPLEX	INTEGER INTEGER
`RADIX`	Base of the model.	1 1	INTEGER REAL	INTEGER INTEGER
`RANGE`	Decimal exponent range.	1 1 1	INTEGER REAL COMPLEX	INTEGER INTEGER INTEGER
`SELECTED_ INT_KIND`	Kind-type titlemeter in range.	1	INTEGER	INTEGER
`SELECTED_ REAL_KIND`	Kind-type titlemeter in range. **Syntax:** `SELECTED _ REAL_KIND(P [,R])` where `P` is precision and `R` is the range.	1 2	INTEGER INTEGER, INTEGER	INTEGER, INTEGER
`TINY`	Smallest positive number that can be represented.	1	REAL	REAL

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6.2.10 Array inquiry functions

Functions for determining information about an array.

Table 6-11: Array inquiry functions

Intrinsic	Description	Num. of Arguments	Argument Type	Result
ALLOCATED	Determine if an array is allocated.	1	ARRAY	LOGICAL
LBOUND	Determine the lower bounds.	1 2	ARRAY ARRAY, INTEGER	INTEGER
SHAPE	Determine the shape.	1	Any	INTEGER
SIZE	Determine the number of elements.	1 2	ARRAY ARRAY, INTEGER	INTEGER
UBOUND	Determine the upper bounds.	1 2	ARRAY ARRAY, INTEGER	INTEGER

6.2.11 Transfer functions

Functions for transferring types.

Table 6-12: Transfer functions

Intrinsic	Description	Num. of Arguments	Argument Type	Result
TRANSFER	Change the type but maintain bit representation.	2 3	Any, Any Any, Any, INTEGER	Any*

*Must be of the same type as the second argument

6.2.12 Arithmetic functions

Functions for manipulating arithmetic.

Table 6-13: Arithmetic functions

Intrinsic	Description	Num. of Arguments	Argument Type	Result
ABS	Return absolute value of the supplied argument.	1	INTEGER, REAL, or COMPLEX	INTEGER, REAL, or COMPLEX
ACOS	Return the arccosine (in radians) of the specified value.	1	REAL	REAL
ACOSD	Return the arccosine (in degrees) of the specified value.	1	REAL	REAL

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Intrinsic	Description	Num. of Arguments	Argument Type	Result
AIMAG	Return the value of the imaginary part of a complex number.	1	COMPLEX	REAL
AINT	Truncate the supplied value to a whole number.	2	REAL INTEGER	REAL
AND	Perform a logical AND on corresponding bits of the arguments.	2	Any, except CHAR or COMPLEX	INTEGER or LOGICAL
ANINT	Return the nearest whole number to the supplied argument.	2	REAL, INTEGER	REAL
ASIN	Return the arcsine (in radians) of the specified value.	1	REAL	REAL
ASIND	Return the arcsine (in degrees) of the specified value.	1	REAL	REAL
ATAN	Return the arctangent (in radians) of the specified value.	1	REAL	REAL
ATAN2	Return the arctangent (in radians) of the specified pair of values.	2	REAL, REAL	REAL
ATAN2D	Return the arctangent (in degrees) of the specified pair of values.	1	REAL, REAL	REAL
ATAND	Return the arctangent (in degrees) of the specified value.	1	REAL	REAL
CEILING	Return the least integer greater than or equal to the supplied real argument.	2	REAL, KIND	INTEGER
CMPLX	Convert the supplied argument or arguments to complex type.	2 3	{INTEGER, REAL, or COMPLEX,}, {INTEGER, REAL, or COMPLEX} {INTEGER, REAL, or COMPLEX}, {INTEGER or REAL}, KIND	COMPLEX COMPLEX
COMPL	Perform a logical complement on the argument.	1	Any, except CHAR or COMPLEX	N/A
COS	Return the cosine (in radians) of the specified value.	1	REAL COMPLEX	REAL
COSD	Return the cosine (in degrees) of the specified value.	1	REAL COMPLEX	REAL

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Intrinsic	Description	Num. of Arguments	Argument Type	Result
COSH	Return the hyperbolic cosine of the specified value.	1	REAL	REAL
DBLE	Convert to double precision real.	1	INTEGER, REAL, or COMPLEX	REAL
DCMPLX	Convert the argument or supplied arguments to double complex type.	1 2	INTEGER, REAL, or COMPLEX INTEGER, REAL	DOUBLE COMPLEX DOUBLE COMPLEX
DPROD	Double precision real product.	2	REAL, REAL	REAL (double precision)
EQV	Perform a logical exclusive NOR on the arguments.	2	Any, except CHAR or COMPLEX	INTEGER or LOGICAL
EXP	Exponential function.	1	REAL COMPLEX	REAL COMPLEX
EXPONENT	Return the exponent part of a real number.	1	REAL	INTEGER
FLOOR	Return the greatest integer less than or equal to the supplied real argument.	1 2	REAL REAL, KIND	REAL KIND
FRACTION	Return the fractional part of a real number.	1	REAL	INTEGER
IINT	Convert a value to a short integer type.	1	INTEGER, REAL, or COMPLEX	INTEGER
ININT	Return the nearest short integer to the real argument.	1	REAL	INTEGER
INT	Convert a value to integer type.	1 2	INTEGER, REAL, or COMPLEX {INTEGER, REAL, or COMPLEX}, KIND	INTEGER INTEGER
INT8	Convert a real value to a long integer type.	1	REAL	INTEGER
IZEXT	Zero-extend the argument.	1	LOGICAL or INTEGER	INTEGER
JINT	Convert a value to an integer type.	1	INTEGER, REAL, or COMPLEX	INTEGER
JNINT	Return the nearest integer to the real argument.	1	REAL	INTEGER
KNINT	Return the nearest integer to the real argument.	1	REAL	INTEGER (long)
LOG	Return the natural logarithm.	1	REAL or COMPLEX	REAL
LOG10	Return the common logarithm.	1	REAL	REAL
MAX	Return the maximum value of the supplied arguments.	2 or more	INTEGER or REAL (all of same kind)	Same as argument type

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Intrinsic	Description	Num. of Arguments	Argument Type	Result
MIN	Return the minimum value of the supplied arguments.	2 or more	INTEGER or REAL (all of same kind)	Same as argument type
MOD	Find the remainder.	2 or more	{INTEGER or REAL}, {INTEGER or REAL} (all of same kind)	Same as argument type
MODULO	Return the modulo value of the arguments.	2 or more	{INTEGER or REAL}, {INTEGER or REAL} (all of same kind)	Same as argument type
NEAREST	Return the nearest different number that can be represented, by a machine, in a given direction.	2	REAL, REAL (nonzero)	REAL
NEQV	Perform a logical exclusive OR on the arguments.	2	Any, except CHAR or COMPLEX	INTEGER or LOGICAL
NINT	Convert a value to integer type.	1 2	REAL REAL, KIND	INTEGER
REAL	Convert the argument to real.	1 2	INTEGER, REAL, or COMPLEX {INTEGER, REAL, or COMPLEX}, KIND	REAL REAL
RRSPACING	Return the reciprocal of the relative spacing of model numbers near the argument value.	1	REAL	REAL
SET_ EXPONENT	Return the model number whose fractional part is the fractional part of the model representation of the first argument and whose exponent part is the second argument.	2	REAL, INTEGER	REAL
SIGN	Return the absolute value of A times the sign of B. Syntax: SIGN(A, B)	2	{INTEGER or REAL}, {INTEGER or REAL}	Same as argument
SIN	Return the sine (in radians) of the specified value.	1	REAL or COMPLEX	REAL
SIND	Return the sine (in degrees) of the specified value.	1	REAL or COMPLEX	REAL
SINH	Return the hyperbolic sine of the specified value.	1	REAL	REAL
SPACING	Return the relative spacing of model numbers near the argument value.	1	REAL	REAL
SQRT	Return the square root of the argument.	1	REAL or COMPLEX	REAL or COMPLEX

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Intrinsic	Description	Num. of Arguments	Argument Type	Result
TAN	Return the tangent (in radians) of the specified value.	1	REAL	REAL
TAND	Return the tangent (in degrees) of the specified value.	1	REAL	REAL
TANH	Return the hyperbolic tangent of the specified value.	1	REAL	REAL

6.2.13 Miscellaneous functions

Functions for mixcellaneous use.

Table 6-14: Miscellaneous functions

Intrinsic	Description	Num. of Arguments	Argument Type	Result
LOC	Return the argument address.	1	NUMERIC	INTEGER
NULL	Assign a disassociated status.	0 1	POINTER	POINTER POINTER

6.2.14 Subroutines

Supported subroutines.

Table 6-15: Subroutines

Intrinsic	Description	Num. of Arguments	Argument Type
CPU_TIME	Return processor time.	1	REAL (OUT)
DATE_AND_TIME	Return the date and time.	4 (all optional)	DATE (CHARACTER, OUT) TIME (CHARACTER, OUT) ZONE (CHARACTER, OUT) VALUES (INTEGER, OUT)
RANDOM_NUMBER	Generate pseudo-random numbers.	1	REAL (OUT)
RANDOM_SEED	Set or query pseudo-random number generator.	1 1 1	SIZE (INTEGER, OUT) PUT (INTEGER ARRAY, IN) GET (INTEGER ARRAY, OUT)

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Intrinsic	Description	Num. of Arguments	Argument Type
SYSTEM_CLOCK	Query the real time clock.	3 (optional)	COUNT (INTEGER, OUT) COUNT_RATE (REAL, OUT) COUNT_MAX (INTEGER, OUT)

6.2.15 Fortran 2003 functions

Fortran 2003-supported functions.

Table 6-16: Fortran 2003 functions

Intrinsic	Description	Num. of Arguments	Argument Type	Result
COMMAND _ARGUMENT _COUNT	Return a scalar of type default integer that is equal to the number of arguments that are passed on the command line when the containing program was invoked. If no command arguments are passed, the result is 0.	0	None	INTEGER
EXTENDS_TYPE _OF	Determine whether the dynamic type of A is an extension type of the dynamic type of B. **Syntax:** EXTENDS_TYPE _OF(A, B)	2	Objects of extensible type	LOGICAL SCALAR
GET_COMMAND _ ARGUMENT	Return the specified command line argument of the command that invoked the program.	1 to 4	INTEGER plus optionally: CHAR, INTEGER, INTEGER	A command argument
GET_COMMAND	Return the entire command line that was used to invoke the program.	0 to 3	CHAR, INTEGER, INTEGER	A command line
GET_ENVIRONM ENT_ VARIABLE	Return the value of the specified environment variable.	1 to 5	CHAR, CHAR, INTEGER, INTEGER, LOGICAL	Stores the value of NAME in VALUE
IS_IOSTAT _END	Test whether a variable has the value of the I/O status: 'end of file'.	1	INTEGER	LOGICAL
IS_IOSTAT _EOR	Test whether a variable has the value of the I/O status: 'end of record'.	1	INTEGER	LOGICAL
LEADZ	Count the number of leading zero bits.	1	INTEGER or bits	INTEGER
MOVE_ALLOC	Move an allocation from one allocatable object to another.	2	Any type and rank	None
NEW_LINE	Return the newline character.	1	CHARACTER	CHARACTER

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Intrinsic	Description	Num. of Arguments	Argument Type	Result
SAME_TYPE _AS	Determine whether the dynamic type of A is the same as the dynamic type of B. **Syntax:** SAME_TYPE_AS (A, B)	2	Objects of extensible type	LOGICAL SCALAR
SCALE	Return the value A * B where B is the base of the number system in use for A. **Syntax:** SCALE(A, B)	2	REAL, INTEGER	REAL

6.2.16 Fortran 2008 functions

Fortran 2008-supported functions.

Table 6-17: Fortran 2008 functions

Intrinsic	Description	Num. of Arguments	Argument Type	Result
ACOSH ASINH ATANH	Inverse hyperbolic trigonometric functions	1	REAL	REAL
BESSEL_J0 BESSEL_J1 BESSEL_JN BESSEL_Y0 BESSEL_Y1 BESSEL_YN	Bessel function of: (J0) the first kind of order 0. (J1) the first kind of order 1. (JN) the first kind. (Y0) the second kind of order 0. (Y1) the second kind of order 1. (YN) the second kind.	1 1 2 or 3 1 1 2 or 3	REAL REAL {INTEGER, REAL, or INTEGER}, INTEGER, REAL REAL REAL {INTEGER, REAL, or INTEGER}, INTEGER, REAL	REAL REAL REAL REAL REAL REAL

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Intrinsic	Description	Num. of Arguments	Argument Type	Result
C_SIZEOF	Calculates the number of bytes of storage the expression A 'occupies'. **Syntax:** C_SIZEOF(A)	1	Any	INTEGER
COMPILER_OPTIONS	Options passed to the compiler.	None	None	STRING
COMPILER_VERSION	Compiler version string.	None	None	CHARACTER
ERF	Error function.	1	REAL	REAL
ERFC	Complementary error function.	1	REAL	REAL
ERFC_SCALED	Exponentially-scaled complementary error function.	1	REAL	REAL
FINDLOC	Finds the location of a specified value in an array. **Syntax:** FINDLOC(ARRAY, VALUE, DIM, MASK, KIND, BACK) Or FINDLOC(ARRAY, VALUE, MASK , KIND, BACK)	3 to 6	ARRAY VALUE, DIM[, MASK, KIND, BACK] Or ARRAY, VALUE[, MASK, KIND, BACK]	INTEGER ARRAY
GAMMA	Computes Gamma of A. For positive, integer values of X.	1	REAL (not zero or negative)	REAL
LOG_GAMMA	Computes the natural logarithm of the absolute value of the Gamma function.	1	REAL (not zero or negative)	REAL
HYPOT	Euclidean distance function.	2	REAL, REAL	REAL
IS_CONTIGUOUS	Tests the contiguity of an array.	1	ARRAY	LOGICAL

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Intrinsic	Description	Num. of Arguments	Argument Type	Result
NORM2	Euclidean vector norm. **Syntax:** NORM2(X[, DIM]) Where: * X shall be a REAL ARRAY. * DIM is an INTEGER SCALAR with a value in the range of 1 to n (where n is the rank of X). **Note:** The current implementation experiences overflow for arguments containing elements whose square is at the boundary value for double-precision floating-point numbers. There is no such overflow for single-precision arguments.	1[, or 2]	REAL ARRAY[, INTEGER SCALAR]	The result is the same type as X. If DIM is not present, the result is SCALAR. If DIM is present, the result has rank n−1 and shape [d1,d2,...,dDIM−1,DIM+1, ...,dn], where n is the rank of X, and [d1,d2,...,dn] is the shape of X.
LEADZ	Returns the number of leading zero bits of an integer.	1	INTEGER	INTEGER
POPCNT	Return the number of one bits.	1	INTEGER	INTEGER
POPPAR	Return the bitwise parity.	1	INTEGER	INTEGER
SELECTED_REAL_KIND	Kind type titlemeter in range. **Syntax:** SELECTED_REAL_KIND(P[, R, RADIX]) where P is precision and R is the range. **Note:** Radix argument added for F2008.	1 2 3	INTEGER INTEGER, INTEGER INTEGER, INTEGER, INTEGER	INTEGER INTEGER INTEGER
STORAGE_SIZE	Storage size of argument A, in bits. **Syntax:** STORAGE_SIZE(A[, KIND])	1[, 2]	SCALAR or ARRAY[, INTEGER]	INTEGER
TRAILZ	Number of trailing zero bits of an integer.	1	INTEGER	INTEGER

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6.2.17 Unsupported functions

Unsupported Fortran 2008 functions:

Table 6-18: Unsupported functions

Intrinsic	Description	Num. of Arguments	Argument Type	Result

`ACOSH`
`ASINH`
`ATANH`
	Inverse hyperbolic trigonometric functions.	1	COMPLEX	COMPLEX

`BGE`
`BGT`
`BLE`
`BLT`
	Bitwise greater than or equal to.
	Bitwise greater than.
	Bitwise less than or equal to.
	Bitwise less than.
		2
		2
		2
		2
			INTEGER, INTEGER
			INTEGER, INTEGER
			INTEGER, INTEGER
			INTEGER, INTEGER
				LOGICAL
				LOGICAL
				LOGICAL
				LOGICAL

`DSHIFTL` `DSHIFTR`	Combined left shift. Combined right shift.	3 3	INTEGER or BOZ constant, INTEGER or BOZ constant, INTEGER INTEGER or BOZ constant, INTEGER or BOZ constant, INTEGER	INTEGER INTEGER"

`IALL`
`IANY`
`IPARITY`
	Bitwise `AND` of array elements.
	Bitwise `OR` of array elements.
	Bitwise `XOR` of array elements.
	Syntax:
	`IALL(ARRAY[, DIM[, MASK]])`
	`IANY(ARRAY[, DIM[, MASK]])`
	`IPARITY(ARRAY[, DIM[, MASK]])`
		1
		1
		1
			ARRAY
			ARRAY
			ARRAY
				ARRAY
				ARRAY
				ARRAY

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Intrinsic	Description	Num. of Arguments	Argument Type	Result
IMAGE_INDEX	Co-subscript to image index conversion.	2	COARRAY, INTEGER	INTEGER
NUM_IMAGES	Number of images.	0, 1, or 2	None, INTEGER, or INTEGER, LOGICAL	INTEGER
THIS_IMAGE	Co-subscript index of this image.	0, 1, or 2	None, INTEGER, INTEGER or COARRAY, INTEGER	INTEGER
LCOBOUND	Lower co-dimension of bounds of an array.	1	COARRAY	INTEGER

UCOBOUND	Upper co-dimension of bounds of an array.
	Syntax:
	`LCOBOUND(COARRAY[, DIM[, KIND]])`
	`UCOBOUND(COARRAY[, DIM[, KIND]])`
		1	COARRAY	INTEGER

MASKL	Left justified mask.	1[, or 2]	INTEGER[, INTEGER]	INTEGER

MASKR	Right justified mask.
	Syntax:
	`MASKL(I[, KIND])`
	`MASKR(I[, KIND])`
		1[, or 2]	INTEGER[, INTEGER]	INTEGER

MERGE_BITS	Merge of bits under mask.	3	INTEGER, INTEGER, INTEGER	INTEGER
PARITY	Reduction with exclusive OR. **Syntax:** `PARITY(MASK[, DIM])`	1[, or 2]	LOGICAL ARRAY[,INTEGER]	LOGICAL
SHIFTA	Right shift with fill.	2	INTEGER, INTEGER	INTEGER
SHIFTL	Left shift.	2	INTEGER, INTEGER	INTEGER
SHIFTR	Right shift.	2	INTEGER, INTEGER	INTEGER

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6.2.18 Unsupported subroutines

Unsupported Fortran 2008 subroutines:

Table 6-19: Unsupported subroutines

Intrinsic	Description	Num. of Arguments	Argument Type
`ATOMIC_DEFINE`	Defines the variable ATOM with the value VALUE atomically. **Syntax:** `ATOMIC_DEFINE(ATOM, VALUE[, STAT])`	2[, or 3]	{INTEGER or LOGICAL}, {INTEGER or LOGICAL}[, INTEGER]
`ATOMIC_REF`	Atomically assigns the value of the variable ATOM to VALUE. **Syntax:** `ATOMIC_REF(ATOM, VALUE[, STAT ])`	2[, or 3]	{INTEGER or LOGICAL}, {INTEGER or LOGICAL}[, INTEGER]
`EXECUTE_COMMAND_LINE`	Execute a shell command. **Syntax:** `EXECUTE_COMMAND_LINE(COMMAND[, WAIT, EXITSTAT, CMDSTAT, CMDMSG])`	1	STRING

6.3 Statements

Describes the Fortran statements that are supported in Arm® Fortran Compiler.

The Fortran statements that are supported in the Arm Fortran Compiler, are:

Table 6-20: Supported Fortran statements

Statement	Language standard	Brief description
ACCEPT	F77	Causes formatted input to be read on standard input.
ALLOCATABLE	F90	Specifies that an array with fixed rank, but deferred shape, is available for a future ALLOCATE statement.
ALLOCATE	F90	Allocates storage for each allocatable array, pointer object, or pointer-based variable that appears in the statements; declares storage for deferred-shape arrays. **Note:** Arm Fortran Compiler does not initialize arrays or variables with zeros. It is best practice to not assume that arrays are filled with zeros when created.

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Statement	Language standard	Brief description
ASSIGN	F77	Assigns a statement label to a variable. **Note:** This statement is a deleted feature in the Fortran standard, but remains supported in the Arm Fortran Compiler.
ASSOCIATE	F2003	Associates a name either with a variable or with the value of an expression, while in a block.
ASYNCHRONOUS	F77	Warns the compiler that incorrect results might occur for optimizations involving movement of code across wait statements, or statements that cause wait operations.
BACKSPACE	F77	Positions the file that is connected to the specified unit, to before the preceding record.

BLOCK	F08	Indicates where a BLOCK construct starts. The BLOCK construct defines an executable block of statements or constructs that can contain declarations. This allows you to declare variables closer to where they are used in your code.
		
		Note:
		• To retain the status and value of a local variable of a BLOCK construct after the block ends, use the SAVE attribute.
		• SAVE-ed statements external to a block do not affect the local variables used internally in a block.
		• Control can not be transferred into a block from outside the block, except when the return is from a procedure call. Transfers in or out of the block are permitted.
		Syntax
		
		`<optional-name> BLOCK`
		`  <optional-specification-part> ! One or more specification statements`
		`  <statement-block>`
		`  ! Zero or more statements or constructs`
		`END BLOCK <optional-name>`
		
		The following specification statements are not permitted:
		• COMMON
		• EQUIVALENCE
		• IMPLICIT
		• INTENT
		• NAMELIST
		• OPTIONAL
		• SUBROUTINE
		• VALUE

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Statement	Language standard	Brief description
BLOCK DATA	F77	Introduces several non-executable statements that initialize data values in COMMON tables.
BYTE	F77 ext	Establishes the data type of a variable by explicitly attaching the name of a variable to a 1-byte integer, overriding implied data typing.
CALL	F77	Transfers control to a subroutine.
CASE	F90	Begins a case-statement-block portion of a SELECT CASE statement.
CHARACTER	F90	Establishes the data type of a variable by explicitly attaching the name of a variable to a character data type, overriding the implied data typing. **Note:** This statement has been marked as obsolescent. Obsolescent statements are now redundant and might be removed from future standards. This statement remains supported in the Arm Fortran Compiler.
CLOSE	F77	Terminates the connection of the specified file to a unit.
COMMON	F77	Defines global blocks of storage that are either sequential or non-sequential. Can be either static or dynamic form. **Note:** This statement has been marked as obsolescent. Obsolescent statements are now redundant and might be removed from future standards. This statement remains supported in the Arm Fortran Compiler.
COMPLEX	F90	Establishes the data type of a variable by explicitly attaching the name of a variable to a complex data type, overriding implied data typing.
CONTAINS	F90 F2003	Precedes a subprogram, a function or subroutine, and indicates the presence of the subroutine or function definition inside a main program, external subprogram, or module subprogram. In F2003, a CONTAINS statement can also appear in a derived type immediately before any type-bound procedure definitions.
CONTINUE	F77	Passes control to the next statement.
CYCLE	F90	Interrupts a DO construct execution and continues with the next iteration of the loop.
DATA	F77	Assigns initial values to variables before execution. **Note:** This statement amongst execution statements has been marked as obsolescent. This functionality is redundant and might be removed from future standards. This statement remains supported in the Arm Fortran Compiler.

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Statement	Language standard	Brief description
DEALLOCATE	F90	Causes the memory that is allocated for each pointer-based variable or allocatable array that appears in the statement to be deallocated (freed). Also might be used to deallocate storage for deferred-shape arrays.
DECODE	F77 ext	Transfers data between variables or arrays in internal storage and translates that data from character form to internal form, according to format specifiers.
DIMENSION	F90	Defines the number of dimensions in an array and the number of elements in each dimension.
DO (Iterative)	F90	Introduces an iterative loop and specifies the loop control index and parameters. **Note:** Label form DO statements have been marked as obsolescent. Obsolescent statements are now redundant and might be removed from future standards. This statement remains supported in the Arm Fortran Compiler.
DO WHILE	F77	Introduces a logical DO loop and specifies the loop control expression.
DOUBLE COMPLEX	F77	Establishes the data type of a variable by explicitly attaching the name of a variable to a double complex data type. This overrides the implied data typing.
DOUBLE PRECISION	F90	Establishes the data type of a variable by explicitly attaching the name of a variable to a double precision data type, overriding implied data typing.
ELSE	F77	Begins an ELSE block of an IF block, and encloses a series of statements that are conditionally executed.
ELSE IF	F77	Begins an ELSE IF block of an IF block series, and encloses statements that are conditionally executed.
ELSE WHERE	F90	The portion of the WHERE ELSE WHERE construct that permits conditional masked assignments to the elements of an array, or to a scalar, zero-dimensional array.
ENCODE	F77 ext	Transfers data between variables or arrays in internal storage and translates that data from internal to character form, according to format specifiers.
END	F77	Terminates a segment of a Fortran program.
END ASSOCIATE	F2003	Terminates an ASSOCIATE block.
END DO	F77	Terminates a DO or DO WHILE loop.
END FILE	F77	Writes an ENDFILE record to the files.
END IF	F77	Terminates an IF ELSE or ELSE IF block.
END MAP	F77 ext	Terminates a MAP declaration.
END SELECT	F90	Terminates a SELECT declaration.
END STRUCTURE	F77 ext	Terminates a STRUCTURE declaration.
END UNION	F77 ext	Terminates a UNION declaration.
END WHERE	F90	Terminates a WHERE ELSE WHERE construct.

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Statement	Language standard	Brief description
ENTRY	F77	Allows a subroutine or function to have more than one entry point. **Note:** This statement has been marked as obsolescent. Obsolescent statements are now redundant and might be removed from future standards. This statement remains supported in the Arm Fortran Compiler.
EQUIVALENCE	F77	Allows two or more named regions of data memory to share the same start address. **Note:** This statement has been marked as obsolescent. Obsolescent statements are now redundant and might be removed from future standards. This statement remains supported in the Arm Fortran Compiler.
ERROR STOP	F2008	Stops the program execution and prevents any further execution of the program. ERROR STOP is similar to STOP, but ERROR STOP indicates that the program terminated in an error condition. **Note:** Also see STOP.
EXIT	F90	Interrupts a DO construct execution and continues with the next statement after the loop.
EXTERNAL	F77	Identifies a symbolic name as an external or dummy procedure which can then be used as an argument.
FINAL	F2003	Specifies a final subroutine inside a derived type.
FORALL	F95	Provides, as a statement or construct, a parallel mechanism to assign values to the elements of an array. **Note:** This statement has been marked as obsolescent. Obsolescent statements are now redundant and might be removed from future standards. This statement remains supported in the Arm Fortran Compiler.
FORMAT	F77	Specifies format requirements for input or output.
FUNCTION	F77	Introduces a program unit; all the statements that follow apply to the function itself.
GENERIC	F2003	Specifies a generic type-bound procedure inside a derived type.
GOTO (Assigned)	F77	Transfers control so that the statement identified by the statement label is executed next. **Note:** This statement is a deleted feature in the Fortran standard, but remains supported in the Arm Fortran Compiler.

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Statement	Language standard	Brief description
GOTO (Computed)	F77	Transfers control to one of a list of labels, according to the value of an expression. **Note:** This statement has been marked as obsolescent. Obsolescent statements are now redundant and might be removed from future standards. This statement remains supported in the Arm Fortran Compiler.
GOTO (Unconditional)	F77	Unconditionally transfers control to the statement with the label, which must be declared in the code of the program unit containing the GOTO statement, and also must be unique in that program unit.
IF (Arithmetic)	F77	Transfers control to one of three labeled statements, depending on the value of the arithmetic expression. **Note:** This statement has been marked as obsolescent. Obsolescent statements are now redundant and might be removed from future standards. This statement remains supported in the Arm Fortran Compiler.
IF (Block)	F77	Consists of a series of statements that are conditionally executed.
IF (Logical)	F77	Executes or does not execute a statement based on the value of a logical expression.
IMPLICIT	F77	Redefines the implied data type of symbolic names from their initial letter, overriding implied data types.
IMPORT	F2003	Gives access to the named entities of the containing scope.
INCLUDE	F77 ext	Directs the compiler to start reading from another file.
INQUIRE	F77	Inquires about the current properties of a particular file or the current connections of a particular unit.
INTEGER	F77	Establishes the data type of a variable by explicitly attaching the name of a variable to an integer data type, overriding implied data types.
INTENT	F90	Specifies the intended use of a dummy argument, but can not be used in a specification statement of a main program.
INTERFACE	F90	Makes an implicit procedure an explicit procedure where the dummy parameters and procedure type are known to the calling module; Also overloads a procedure name.
INTRINSIC	F77	Identifies a symbolic name as an intrinsic function and allows it to be used as an actual argument.
LOGICAL	F77	Establishes the data type of a variable by explicitly attaching the name of a variable to a logical data type, overriding implied data types.
MAP	F77 ext	Designates each unique field or group of fields in a UNION statement.

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Statement	Language standard	Brief description
MODULE	F90	Specifies the entry point for a Fortran 90, or Fortran 95, module program unit. A module defines a host environment of scope of the module, and might contain subprograms that are in the same scoping unit.
NAMELIST	F90	Allows the definition of NAMELIST groups for NAMELIST-directed I/O.
NULLIFY	F90	Disassociates a pointer from its target.
OPEN	F77	Connects an existing file to a unit, creates and connects a file to a unit, creates a file that is pre-connected, or changes certain specifiers of a connection between a file and a unit.
OPTIONAL	F90	Specifies dummy arguments that can be omitted or that are optional.
OPTIONS	F77 ext	Confirms or overrides certain compiler command-line options.
PARAMETER	F77	Gives a symbolic name to a constant.
PAUSE	F77	Stops program execution. **Note:** This statement is a deleted feature in the Fortran standard, but remains supported in the Arm Fortran Compiler.
POINTER	F90	Provides a means for declaring pointers.
PRINT	F77	Transfers data to the standard output device from the items that are specified in the output list and format specification.
PRIVATE	F90 F2003	Specifies that entities that are defined in a module are not accessible outside of the module. PRIVATE can also appear inside a derived type to disallow access to its data components outside the defining module. In F2003, to disallow access to type-bound procedures outside the defining module, a PRIVATE statement can appear after a CONTAINS statement, in a derived type.
PROCEDURE	F2003	Specifies a type-bound procedure, procedure pointer, module procedure, dummy procedure, intrinsic procedure, or an external procedure.
PROGRAM	F77	Specifies the entry point for a linked Fortran program.
PROTECTED	F2003	Protects a module variable against modification from outside the module in which it was declared.
PUBLIC	F90	Specifies that entities that are defined in a module are accessible outside of the module.
PURE	F95	Indicates that a function or subroutine has no side effects.
READ	F77	Transfers data from the standard input device to the items specified in the input and format specifications.
REAL	F90	Establishes the data type of a variable by explicitly attaching the name of a variable to a data type, overriding implied data types.

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Statement	Language standard	Brief description
RECORD	F77 ext	A VAX Fortran extension, defines a user-defined aggregate data item.
RECURSIVE	F90	Indicates whether a function or subroutine can call itself recursively.
RETURN	F77	When used in a subroutine, causes a return to the statement following a CALL. When used in a function, returns to the relevant arithmetic expression. **Note:** This statement has been marked as obsolescent. Obsolescent statements are now redundant and might be removed from future standards. This statement remains supported in the Arm Fortran Compiler.
REWIND	F77	Positions the file at the start. The statement has no effect if the file is already positioned at the start, or if the file is connected but does not exist.
SAVE	F77	Retains the definition status of an entity after a RETURN or END statement in a subroutine or function that has been executed.
SELECT CASE	F90	Begins a CASE construct.
SELECT TYPE	F2003	Provides the capability to execute alternative code depending on the dynamic type of a polymorphic entity, and to gain access to dynamic parts. The alternative code is selected using the TYPE IS statement for a specific dynamic type, or the CLASS IS statement for a specific type (and all its type extensions). Use the optional class default statement to specify all other dynamic types that do not match a specified TYPE IS or CLASS IS statement. Like the CASE construct, the code consists of a several blocks and, at most, one is selected for execution.
SEQUENCE	F90	A derived type qualifier that specifies the ordering of the storage that is associated with the derived type. This statement specifies storage for use with COMMON and EQUIVALENCE statements.
STOP	F77	Stops program execution and precludes any further execution of the program. **Note:** Also see ERROR STOP.
STRUCTURE	F77 ext	A VAX extension to FORTRAN 77 that defines an aggregate data type.
SUBROUTINE	F77	Introduces a subprogram unit.
TARGET	F90	Specifies that a data type can be the object of a pointer variable (for example, pointed to by a pointer variable). Types that do not have the TARGET attribute cannot be the target of a pointer variable.
THEN	F77	Part of an IF block statement, surrounds a series of statements that are conditionally executed.

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Statement	Language standard	Brief description
TYPE	F90 F2003	Begins a derived type data specification or declares variables of a specified user-defined type. Use the optional EXTENDS statement with TYPE to indicate a type extension in F2003.
UNION	F77 ext	A multi-statement declaration defining a data area that can be shared intermittently during program execution by one or more fields or groups of fields.
USE	F90	Gives a program unit access to the public entities or to the named entities in the specified module.
VOLATILE	F77 ext	Inhibits all optimizations on the variables, arrays and common blocks that it identifies.
WAIT	F2003	Performs a wait operation for specified pending asynchronous data transfer operations.
WHERE	F90	Permits masked assignments to the elements of an array or to a scalar, zero-dimensional array.
WRITE	F77	Transfers data to the standard output device from the items that are specified in the output list and format specification.

*See WG5 Fortran Standards

The denoted language standards indicate the standard that they were introduced in, or the standard that they were last significantly changed.

Related information

WG5 Fortran Standards

6.4 Predefined macro support

Discusses predefined macro support in Arm® Fortran Compiler.

In Arm Fortran Compiler, the predefined macros are object-like macros (similar to C predefined macros).

Predefined macros are available to use in preprocessor statements in your code and allow you to check properties at compile time, and if required, change the code in response to those properties. The properties could be about the compiler, the compilation options, or the system being targeted.

Arm Fortran Compiler supports the following predefined macros:

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Table 6-21: Pre-defined macros

Macro	Value	Purpose
`__ARM_LINUX_COMPILER__`	1	Defined as an integer value and expands to `1` to indicate Arm Compiler for Linux.
`__ARM_LINUX_COMPILER_BUILD__`	INTEGER	Defined as an integer value and expands to the Arm Compiler for Linux build number.
`__armclang_major__`	INTEGER	Defined as an integer value and expands to the Arm Compiler for Linux major version number.
`__armclang_minor__`	INTEGER	Defined as an integer value and expands to the Arm Compiler for Linux minor version number.
`__armclang_version__`	STRING	Defined as a string value and expands to the full Arm Compiler for Linux version number.
`__DATE__`	STRING	Defined as a string value (format `mmm dd yyyy`) and expands to the current date.
`__FILE__`	STRING	Defined as a string value and expands to the filename of the current file. Where `__FILE__` reports a filepath in addition to the filename, the filepath is relative to the search path used by the preprocessor to locate the file. `__FILE__` is useful to use with `__LINE__` to identify both a file and line of code.
`__FLANG`	1	Defined as an integer value and expands to `1` to indicate a FLANG-derived compiler. `__FLANG` is often included in Makefiles that support flang compilers.
`__LINE__`	INTEGER	Defined as an integer value and expands to the number of the line of code that contains this macro. `__LINE__` is useful to use with `__FILE__` to identify both a file and line of code.
`_OPENMP`	INTEGER	Defined as a decimal integer literal value and expands to the year and month (`yyyymm`) of the OpenMP standard that is implemented.
`__TIME__`	STRING	Defined as a string value (format `hh:mm:ss`) and expands to the current time.


Note

The preceding list is not exhaustive. Instead, it describes the predefined macros that are considered to be the most useful to use with Arm Fortran Compiler.

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7 Standards support

This chapter describes the support status of Arm® Fortran Compiler with the Fortran language and OpenMP standards.

7.1 Fortran 2003

Details the support status with the Fortran 2003 standard.

Table 7-1: Fortran 2003 support

Fortran 2003 Feature	Support Status
ISO TR 15580 IEEE Arithmetic	Yes
ISO TR 15581 Allocatable Enhancements	
Dummy arrays	Yes
Function results	Yes
Structure components	Yes
Data enhancements and object orientation	
Parameterized derived types	Yes
Procedure pointers	Yes
Finalization	Yes
Procedures that are bound by name to a type	Yes
The PASS attribute	Yes
Procedures that are bound to a type as operators	Yes
Type extension	Yes
Overriding a type-bound procedure	Yes
Enumerations	Yes
ASSOCIATE construct	Yes
Polymorphic entities	Yes
SELECT TYPE construct	Yes
Deferred bindings and abstract types	Yes
Allocatable scalars	Yes
Allocatable character length	Yes
Miscellaneous enhancements	Yes
Structure constructor changes	Yes
Generic procedure interfaces with the same name as a type	Yes
The allocate statement	Yes
Source specifier	Yes
Errmsg specifier	Yes
Assignment to an allocatable array	Yes
Transferring an allocation	Yes

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Fortran 2003 Feature	Support Status
More control of access from a module	Yes
Renaming operators on the USE statement	Yes
Pointer assignment	Yes
Pointer INTENT	Yes
The VOLATILE attribute	Yes One or more issues are observed with this feature.
The IMPORT statement	Yes
Intrinsic modules	Yes
Access to the computing environment	Yes
Support for international character sets	Partial Only `selected_char_kind` is supported.
Lengths of names and statements	
names = 63	Yes
statements = 256	Yes
Binary, octal and hex constants	Yes
Array constructor syntax	Yes
Specification and initialization expressions	Yes A few intrinsics which are not commonly used are not supported.
Complex constants	Yes
Changes to intrinsic functions	Yes
Controlling IEEE underflow	Yes
Another IEEE class value	Yes
I/O enhancements	Yes
Derived type I/O	Yes One or more issues are observed with this feature.
Asynchronous I/O	Yes One or more issues are observed with this feature.
FLUSH statement	Yes
IOMSG= specifier	Yes
Stream access input/output	Yes
ROUND= specifier	Yes Not supported for write.
DECIMAL= specifier	Yes

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Fortran 2003 Feature	Support Status
SIGN= specifier	Yes `processor_defined` does not work for open.
Kind type parameters of integer specifiers	Yes
Recursive input/output	Yes
Intrinsic function for newline character	Yes
Input and output of IEEE exceptional values	Yes Read does not work for NaN(s).
Comma after a P edit descriptor	Yes
Interoperability with	
Interoperability of intrinsic types	Yes
Interoperability with C pointers	Yes
Interoperability of derived types	Yes
Interoperability of variables	Yes
Interoperability of procedures	Yes
Interoperability of global data	Yes


Note

For more information about the features that are listed in the table above, see N1648 - ISO/IEC JTC1/SC22/WG5: The new features of Fortran 2003.

7.2 Fortran 2008

Details the support status with the Fortran 2008 standard.

Table 7-2: Fortran 2008 support

Fortran 2008 feature	Support status
Submodules	Yes
Coarrays	No
Performance enhancements	
do concurrent	Partial The `do concurrent` syntax is accepted. The code that is generated is serial.
Contiguous attribute	Yes
Data Declaration	
Maximum rank + corank = 15	No
Long integers	Yes

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Fortran 2008 feature	Support status
Allocatable components of recursive type	No
Implied-shape array	No
Pointer initialization	No
Data statement restrictions lifted	No
Kind of a forall index	No
Type statement for intrinsic types	No
Declaring type-bound procedures	Yes Supports declaring multiple type-bound procedures in a single procedure statement.
Value attribute is permitted for any nonallocatable nonpointer noncoarray	No
In a pure procedure the intent of an argument need not be specified if it has the value attribute	Yes
Accessing data objects	
Simply contiguous arrays rank remapping to rank>1 target	Yes
Omitting an ALLOCATABLE component in a structure constructor	No
Multiple allocations with SOURCE=	No
Copying the properties of an object in an ALLOCATE statement	Yes
MOLD= specifier for ALLOCATE	Yes
Copying bounds of source array in ALLOCATE	Yes
Polymorphic assignment	No
Accessing real and imaginary parts	Partial Not supported for complex arrays.
Pointer function reference is a variable	No
Elemental dummy argument restrictions lifted	Yes
Input/Output	
Finding a unit when opening a file	Yes
g0 edit descriptor	No
Unlimited format item	Yes
Recursive I/O	Yes
Execution control	
The BLOCK construct	Yes
Exit statement	No
Stop code	Yes
ERROR STOP	Yes
Intrinsic procedures for bit processsing	
Bit sequence comparison	No
Combined shifting	No
Counting bits	Yes
Masking bits	No
Shifting bits	No

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Fortran 2008 feature	Support status
Merging bits	No
Bit transformational functions	No
Intrinsic procedures and modules	
Storage size	Yes
Optional argument RADIX added to SELECTED REAL	No
Extensions to trigonometric and hyperbolic intrinsics	Partial Complex types are not accepted for acosh, asinh and atanh. Also, atan2 cannot be accessed through atan.
Bessel functions	Yes
Error and gamma functions	Yes
Euclidean vector norms	Yes The current implementation experiences overflow for arguments containing elements whose square is at the boundary value for double-precision floating-point numbers. There is no such overflow for single-precision arguments.
Parity	No
Execute command line	No
Optional back argument added to maxloc and minloc	Yes
Find location in an array	Yes
String comparison	Yes
Constants	Yes
COMPILER_VERSION	Yes
COMPILER_OPTIONS	Yes
Function for C sizeof	Yes
Added optional argument for IEEE_SELECTED_REAL_KIND	No
Programs and procedures	
Save attribute for module and submodule data	Partial One or more issues are observed with this feature.
Empty contains section	Partial Not supported for procedures.
Form of end statement for internal and module procedures	Yes
Internal procedure as an actual argument	Yes
Null pointer or unallocated allocatable as absent dummy arg.	Partial Not supported for null pointer.

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Fortran 2008 feature	Support status
Non pointer actual for pointer dummy argument	Yes
Generic resolution by procedureness	No
Generic resolution by pointer vs. allocatable	Yes
Impure elemental procedures	Yes
Entry statement becomes obsolescent	Yes
Source form	
Semicolon at line start	Yes


Note

For more information about the features that are listed in the table above, see N1891 - ISO/IEC JTC1/SC22/WG5: The new features of Fortran 2008.

7.3 OpenMP 4.0

Describes which OpenMP 4.0 features are supported by Arm® Fortran Compiler.

Table 7-3: Supported OpenMP 4.0 features

Open MP 4.0 Feature	Support
C/C++ Array Sections	N/A
Thread affinity policies	Yes
`simd` construct	Partial **Note:** No clauses are supported. To force a loop to vectorize, you can use `!$omp simd`.
`declare simd` construct	No
Device constructs	No
Task dependencies	No
`taskgroup` construct	Yes
User defined reductions	No
Atomic capture swap	Yes
Atomic `seq_cst`	No
Cancellation	Yes
`OMP_DISPLAY_ENV`	Yes

Related information

OpenMP thread mapping

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7.4 OpenMP 4.5

Describes which OpenMP 4.5 features are supported by Arm® Fortran Compiler.

Table 7-4: Supported OpenMP 4.5 features

Open MP 4.5 Feature	Support
`doacross` loop nests with ordered	No
`linear` clause on `loop` construct	No
`simdlen` clause on `simd` construct	No
Task priorities	No
`taskloop` construct	Yes
Extensions to device support	No
`if` clause for combined constructs	Yes
`hint` clause for `critical` construct	No
`source` and `sink` dependence types	No
C++ Reference types in data sharing attribute clauses	N/A
Reductions on C/C++ array sections	N/A
`ref`, `val`, and `uval` modifiers for `linear` clause.	No
Thread affinity query functions	Yes
Hints for lock API	Yes

Related information

OpenMP thread mapping

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8 Supporting reference information

This chapter describes the compatibility of Arm® Fortran Compiler with the gfortran compiler, the relationship between Arm Fortran Compiler and the LLVM Clang compiler and Classic Flang projects, and provides information about the environment variables available in Arm Fortran Compiler.

8.1 Arm Compiler for Linux environment variables

Describes where to find reference information about the environment variables that are available in Arm® Compiler for Linux.

The environment variables that are available to use with both Arm C/C++/Fortran Compiler and Arm Performance Libraries are described on the Environment variables reference for Arm Server and High Performance Computing (HPC) tools Developer webpage.

8.2 gfortran compatibility provided by Arm Fortran Compiler

Arm® Fortran Compiler 22.0.2 is based on Classic Flang and LLVM technology. This topic describes the compatibility of gfortran and Arm Fortran Compiler.

gfortran and Arm Fortran Compiler share some similarities, such as compiler option spelling and option behavior, however there are many differences between the compilers, for example: the default behavior of options, the level of Fortran language support, how Fortran-formatted I/O is handled on read and write operations, and how modules are handled.

Therefore, code that has been written for gfortran is likely to require some modification or recompilation to be compatible with Arm Fortran Compiler. You might have to:

- Change your build scripts or Makefiles to support the different compiler interfaces and options.
- Check the level of Fortran language support offered in each compiler and update your code to comply with the languages supported by Arm Fortran Compiler.
- Modify or update your language extensions. Non-standard library extension support varies between gfortran and Arm Fortran Compiler.

In general, Arm recommends you recompile all source files and libraries:

- Recompile modules file code. gfortran and Arm Fortran Compiler module files are not compatible.
- Recompile code that uses runtime libraries, for example intrinsics, math, and I/O operation code. gfortran and Arm Fortran Compiler use different runtime libraries.
- Recompile code that uses array descriptors. Array descriptor code is specific to a compiler.

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You can find out more about the Fortran standards Arm Fortran Compiler supports in Standards support, and the language features and extensions that Arm Fortran Compiler supports in Fortran language reference.

gfortran to Arm Fortran Compiler migration information is available as part of the HPC application porting guides, see:

- armflang for gfortran users (porting code to Arm Neon)
- armflang for gfortran users (porting code to Arm SVE)

8.3 Classic Flang and LLVM documentation

Arm® Fortran Compiler 22.0.2 is based on two open source projects: LLVM Compiler Infrastructure version (Clang) 13.0.0 (for overall compiler infrastructure), and Classic Flang (for Fortran front-end).

The Arm Fortran Compiler documentation describes the features that are supported in Arm Fortran Compiler. Where possible, the functionality of the open source technology is preserved. This means that there are additional features available in Arm Compiler for Linux that are not listed in the documentation. These additional features are known as community features. For support level definitions, see Support level definitions.

You can find the documentation about how to use the community features at:

- LLVM Clang Compiler documentation
  - The LLVM 13.0.0 Release Notes:

    https://releases.llvm.org/13.0.0/tools/clang/docs/ReleaseNotes.html
- Classic Flang community GitHub web site

Arm Fortran Compiler is based on 13.0.0.

The `third_party_licenses.txt` file includes details of all the open source software projects which are relevant to Arm Compiler for Linux 22.0.2, including the git hashes of the open source projects that Arm Fortran Compiler is based on.

8.4 Support level definitions

This describes the levels of support for various Arm® Compiler for Linux features.

Arm Compiler for Linux is built on open source technology. Therefore, it has more functionality than the set of product features described in the documentation. The following definitions clarify the levels of support and guarantees on functionality that are expected from these features.

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Identification in the documentation

All features that are documented in the Arm Compiler for Linux documentation are product features, except where explicitly stated. The limitations of non-product features are explicitly stated.

Product features

Product features are suitable for use in a production environment. The functionality is well-tested, and is expected to be stable across feature and update releases.

Community features

Arm Compiler for Linux is built on LLVM technology and preserves the functionality of that technology where possible. This means that there are additional features available in Arm Compiler for Linux that are not listed in the documentation. These additional features are known as community features. For information on these community features, see the documentation for the Clang LLVM project and https://releases.llvm.org/13.0.0/tools/clang/docs/ReleaseNotes.html. For Fortran support, also see the Flang community GitHub web site.

Arm Compiler for Linux 22.0.2 is based on Clang 13.0.0.

Where community features are referenced in the documentation, they are indicated with [COMMUNITY].

- Arm makes no claims about the quality level or the degree of functionality of these features, except when explicitly stated in this documentation.
- Functionality might change significantly between releases.

You are responsible for making sure that any generated code that uses unsupported or community features operates correctly.

Some community features might become product features in the future, but Arm provides no roadmap for this. Arm is interested in understanding your use of these features, and welcomes feedback on them.

Deprecated features

A deprecated feature is one that Arm plans to remove from a future release of Arm Compiler for Linux. Arm does not make any guarantee regarding the testing or maintenance of deprecated features. Therefore, Arm does not recommend using a feature after it is deprecated.

For information on replacing deprecated features with supported features, refer to the Arm Compiler for Linux documentation and Release Notes.

Unsupported features

With both the product and community feature categories, specific features and use-cases are known not to function correctly, or are not intended for use with Arm Compiler for Linux.

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Limitations of product features are stated in the documentation. Arm cannot provide an exhaustive list of unsupported features, or unsupported use-cases, for community features.

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9 Troubleshoot

This chapter describes how to diagnose problems when compiling applications using Arm® Fortran Compiler.

9.1 Application segfaults at -Ofast optimization level

A program runs correctly when the binary is built using the `-O3` optimization level, but encounters a runtime crash or segfault with `-Ofast` optimization level.

Condition

The runtime segfault only occurs when `-Ofast` is used to compile the code. The segfault disappears when you add the `-fno-stack-arrays` option to the compile line. .

The `-fstack-arrays` option is enabled by default at `-Ofast`

When the `-fstack-arrays` option is enabled, either on its own or enabled with `-Ofast` by default, the compiler allocates arrays for all sizes using the local stack for local and temporary arrays. This helps to improve performance, because it avoids slower heap operations with `malloc()` and `free()`. However, applications that use large arrays might reach the Linux stack-size limit at runtime and produce program segfaults. On typical Linux systems, a default stack-size limit is set, such as 8192 kilobytes. You can adjust this default stack-size limit to a suitable value.

Solution

Use `-Ofast -fno-stack-arrays` instead. The combination of `-Ofast -fno-stack-arrays` disables automatic arrays on the local stack, and keeps all other `-Ofast` optimizations. Alternatively, to set the stack so that it is larger than the default size, call `ulimit -s unlimited` before running the program.

9.2 Compiling with the -fpic option fails when using GCC compilers

Describes the difference between the `-fpic` and `-fPIC` options when compiling for Arm with GCC and Arm® Compiler for Linux.

Condition

Failure can occur at the linking stage when building Position-Independent Code (PIC) on AArch64 using the lower-case `-fpic` compiler option with GCC compilers (gfortran, gcc, g++), in preference to using the upper-case `-fPIC` option.

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Note

- This issue does not occur when using the `-fpic` option with Arm Compiler for Linux (`armflang/armclang/armclang++`), and it also does not occur on x86_64 because -fpic operates the same as `-fPIC`.
- PIC is code which is suitable for shared libraries.

Cause

Using the `-fpic` compiler option with GCC compilers on AArch64 causes the compiler to generate one less instruction per address computation in the code, and can provide code size and performance benefits. However, it also sets a limit of 32k for the Global Offset Table (GOT), and the build can fail at the executable linking stage because the GOT overflows.


Note

When building PIC with Arm Compiler for Linux on AArch64, or building PIC on x86_64, `-fpic` does not set a limit for the GOT, and this issue does not occur.

Solution

Consider using the `-fPIC` compiler option with GCC compilers on AArch64, because it ensures that the size of the GOT for a dynamically linked executable will be large enough to allow the entries to be resolved by the dynamic loader.

9.3 Error messages when installing Arm Compiler for Linux

If you experience a problem when installing Arm® Compiler for Linux, consider the following points.

- To perform a system-wide install, ensure that you have the correct permissions. If you do not have the correct permissions, the following errors are returned:
  - Systems using RPM Package Manager (RPM):

```
error: can't create transaction lock on /var/lib/rpm/.rpm.lock (Permission
 denied)
```

  - Debian systems using dpkg:

```
dpkg: error: requested operation requires superuser privilege
```

- If you install using the `--install-to <directory>` option, ensure that the system you are installing on has the required rpm or dpkg binaries installed. If it does not, the following errors are returned:
  - Systems using RPM Package Manager (RPM):

```
Cannot find 'rpm' on your PATH. Unable to extract .rpm files.
```

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- Debian systems using dpkg:

```
Cannot find 'dpkg' on your PATH. Unable to extract .deb files.
```

9.4 Error moving Arm Compiler for Linux modulefiles

Describes a workaround to use if you move Arm® Compiler for Linux environment modulefiles.

Moving installed Arm Compiler for Linux modulefiles causes them to stop working

By default, Arm Compiler for Linux modulefiles are configured to find the Arm Compiler for Linux binaries at a location that is relative to the modulefiles.

Moving or copying the modulefiles to a new location means that the installed binaries are no longer at the same relative location to the new modulefile location. When trying to locate binaries, the broken relative links between the new modulefile location and the location of the installed binaries causes the new modulefiles to fail.

Workaround

Move the dependency modulefile directories `/moduledeps` and `module_globals` with the modulefile or modulefile directory you are moving:

- If you move an individual modulefile, such as the `acfl/<package-version>` modulefile, move the `/moduledeps/` and `/module_globals/` modulefile directories to one directory level above the new location of the modulefile you moved.
- If you move the `/modulefiles/` directory, move the `/moduledeps/` and `/module_globals/` modulefile directories to the same new directory location as `/modulefiles/`.

`<package-version>` is equivalent to `<major-version>.<minor-version>{.<patch-version>}`.

Related information

|armcompilersuite| installation instructions

9.5 Code is not bit-reproducible

Describes the compiler options to use to generate bit-reproducible code.

Condition

Code is being compiled with autovectorization enabled (using one of the `-O2`, `-O3`, or `-Ofast` optimization levels, or using `-fvectorize`), and compiled with the `-fsimdmath` option.

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Note

For `armflang`, `-fsimdmath` is enabled by default.

Autovectorization with `-fsimdmath` is preventing bit-reproducibility

The `-fsimdmath` option allows the compiler to generate calls to vectorized library routines. The vectorized library routines might use different algorithms to the scaler routine algorithms, and bit-reproducibility between the two versions is not guaranteed. In other words, both the scalar and vector routines give the same result, but the scalar version might not give the exact same bits as the vector version.

Therefore, when `-fsimdmath` is used on your compile line alongside enabling autovectorization, the compiler might vectorize loops using calls to vectorized math routines, affecting the bit reproducibility.

Solution

If you require your code to be bit reproducible, compile your code using the `-fno-simdmath` option.

9.6 binutils does not automatically unload with module unload

Describes what to do if you have unloaded the Arm® Compiler for Linux modulefile, but still see 'binutils' loaded.

Conditions

The Arm Compiler for Linux modulefile has been loaded for a compiling session, and at the end of the compiling session, the Arm Compiler for Linux modulefile has been unloaded using the `module unload <modulefile>` command.

After unloading the Arm Compiler for Linux modulefile, the 'binutils' modulefile remains loaded. If you use any other utility tools that use 'binutils', such as ld or objdump, they will use the incorrect 'binutils' modulefile on your system.


Note

- If you use `module purge` to unload all loaded modulefiles, you will not experience this issue.
- This unloading behavior applies to both Environment Modules-based systems and lmod environment modules-based systems.

Cause

'binutils' is required by the Arm Compiler for Linux and the binutils modulefile is automatically loaded when the Arm Compiler for Linux modulefile is loaded. However,the 'binutils' modulefile

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is not automatically unloaded when the Arm Compiler for Linux modulefile is unloaded using the `module unload` command.

Workaround

At the end of your compiling session, you must explicitly unload both the Arm Compiler for Linux and 'binutils' modulefiles. Alternatively, you can unload all modulefiles at once, for example, using the `module purge` command.

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