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Using GNU Fortran 95

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For the 4.0.3 Version*

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Short Contents

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Introduction

This manual documents the use of `gfortran`, the GNU Fortran 95 compiler. You can find in this manual how to invoke `gfortran`, as well as its features and incompatibilities.

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To make this approach work, you must insist on numbers that you can compare, such as, "We will donate ten dollars to the Frobnitz project for each disk sold." Don't be satisfied with a vague promise, such as "A portion of the profits are donated," since it doesn't give a basis for comparison.

Even a precise fraction "of the profits from this disk" is not very meaningful, since creative accounting and unrelated business decisions can greatly alter what fraction of the sales price counts as profit. If the price you pay is $50, ten percent of the profit is probably less than a dollar; it might be a few cents, or nothing at all.

Some redistributors do development work themselves. This is useful too; but to keep everyone honest, you need to inquire how much they do, and what kind. Some kinds of development make much more long-term difference than others. For example, maintaining a separate version of a program contributes very little; maintaining the standard version of a program for the whole community contributes much. Easy new ports contribute little, since someone else would surely do them; difficult ports such as adding a new CPU to the GNU Compiler Collection contribute more; major new features or packages contribute the most.

By establishing the idea that supporting further development is "the proper thing to do" when distributing free software for a fee, we can assure a steady flow of resources into making more free software.

1 Getting Started

Gfortran is the GNU Fortran 95 compiler front end, designed initially as a free replacement for, or alternative to, the unix `f95` command; `gfortran` is command you'll use to invoke the compiler.

Gfortran is not yet a fully conformant Fortran 95 compiler. It can generate code for most constructs and expressions, but work remains to be done. In particular, there are known deficiencies with ENTRY, NAMELIST, and sophisticated use of MODULES, POINTERS and DERIVED TYPES. For those whose Fortran codes conform to either the Fortran 77 standard or the GNU Fortran 77 language, we recommend to use `g77` from GCC 3.4. We recommend that distributors continue to provide packages of g77-3.4 until we announce that `gfortran` fully replaces `g77`. The gfortran developers welcome any feedback on user experience with `gfortran` at fortran@gcc.gnu.org.

When `gfortran` is finished, it will do everything you expect from any decent compiler:

- Read a user's program, stored in a file and containing instructions written in Fortran 77, Fortran 90 or Fortran 95. This file contains *source code*.
- Translate the user's program into instructions a computer can carry out more quickly than it takes to translate the instructions in the first place. The result after compilation of a program is *machine code*, code designed to be efficiently translated and processed by a machine such as your computer. Humans usually aren't as good writing machine code as they are at writing Fortran (or C++, Ada, or Java), because is easy to make tiny mistakes writing machine code.
- Provide the user with information about the reasons why the compiler is unable to create a binary from the source code. Usually this will be the case if the source code is flawed. When writing Fortran, it is easy to make big mistakes. The Fortran 90 requires that the compiler can point out mistakes to the user. An incorrect usage of the language causes an *error message*.

  The compiler will also attempt to diagnose cases where the user's program contains a correct usage of the language, but instructs the computer to do something questionable. This kind of diagnostics message is called a *warning message*.
- Provide optional information about the translation passes from the source code to machine code. This can help a user of the compiler to find the cause of certain bugs which may not be obvious in the source code, but may be more easily found at a lower level compiler output. It also helps developers to find bugs in the compiler itself.
- Provide information in the generated machine code that can make it easier to find bugs in the program (using a debugging tool, called a *debugger*, such as the GNU Debugger `gdb`).
- Locate and gather machine code already generated to perform actions requested by statements in the user's program. This machine code is organized into *modules* and is located and *linked* to the user program.

Gfortran consists of several components:

- A version of the `gcc` command (which also might be installed as the system's `cc` command) that also understands and accepts Fortran source code. The `gcc` command is the *driver* program for all the languages in the GNU Compiler Collection (GCC); With `gcc`, you can compiler the source code of any language for which a front end is available in GCC.

- The `gfortran` command itself, which also might be installed as the system's `f95` command. `gfortran` is just another driver program, but specifically for the Fortran 95 compiler only. The difference with `gcc` is that `gfortran` will automatically link the correct libraries to your program.
- A collection of run-time libraries. These libraries contains the machine code needed to support capabilities of the Fortran language that are not directly provided by the machine code generated by the `gfortran` compilation phase, such as intrinsic functions and subroutines, and routines for interaction with files and the operating system.
- The Fortran compiler itself, (`f951`). This is the gfortran parser and code generator, linked to and interfaced with the GCC backend library. `f951` "translates" the source code to assembler code. You would typically not use this program directly; instead, the `gcc` or `gfortran` driver programs will call it for you.

2 GFORTRAN and GCC

GCC used to be the GNU "C" Compiler, but is now known as the *GNU Compiler Collection*. GCC provides the GNU system with a very versatile compiler middle end (shared optimization passes), and with back ends (code generators) for many different computer architectures and operating systems. The code of the middle end and back end are shared by all compiler front ends that are in the GNU Compiler Collection.

A GCC front end is essentially a source code parser and a pass to generate a representation of the semantics of the program in the source code in the GCC language independent intermediate language, called *GENERIC*.

The parser takes a source file written in a particular computer language, reads and parses it, and tries to make sure that the source code conforms to the language rules. Once the correctness of a program has been established, the compiler will build a data structure known as the *Abstract Syntax tree*, or just *AST* or "tree" for short. This data structure represents the whole program or a subroutine or a function. The "tree" is passed to the GCC middle end, which will perform optimization passes on it, pass the optimized AST and generate assembly for the program unit.

Different phases in this translation process can be, and in fact *are* merged in many compiler front ends. GNU Fortran 95 has a strict separation between the parser and code generator.

The goal of the gfortran project is to build a new front end for GCC: A Fortran 95 front end. In a non-gfortran installation, `gcc` will not be able to compile Fortran 95 source code (only the "C" front end has to be compiled if you want to build GCC, all other languages are optional). If you build GCC with gfortran, `gcc` will recognize '`.f/.f90/.f95`' source files and accepts Fortran 95 specific command line options.

3 GFORTRAN and G77

Why do we write a compiler front end from scratch? There's a fine Fortran 77 compiler in the GNU Compiler Collection that accepts some features of the Fortran 90 standard as extensions. Why not start from there and revamp it?

One of the reasons is that Craig Burley, the author of G77, has decided to stop working on the G77 front end. On Craig explains the reasons for his decision to stop working on G77 in one of the pages in his homepage. Among the reasons is a lack of interest in improvements to `g77`. Users appear to be quite satisfied with `g77` as it is. While `g77` is still being maintained (by Toon Moene), it is unlikely that sufficient people will be willing to completely rewrite the existing code.

But there are other reasons to start from scratch. Many people, including Craig Burley, no longer agreed with certain design decisions in the G77 front end. Also, the interface of `g77` to the back end is written in a style which is confusing and not up to date on recommended practice. In fact, a full rewrite had already been planned for GCC 3.0.

When Craig decided to stop, it just seemed to be a better idea to start a new project from scratch, because it was expected to be easier to maintain code we develop ourselves than to do a major overhaul of `g77` first, and then build a Fortran 95 compiler out of it.

4 GNU Fortran 95 Command Options

The `gfortran` command supports all the options supported by the `gcc` command. Only options specific to gfortran are documented here.

Gfortran is not yet a fully conformant Fortran 95 compiler. It can generate code for most constructs and expressions, but work remains to be done. In particular, there are known deficiencies with ENTRY, NAMELIST, and sophisticated use of MODULES, POINTERS and DERIVED TYPES. For those whose Fortran codes conform to either the Fortran 77 standard or the GNU Fortran 77 language, we recommend to use `g77` from GCC 3.4. We recommend that distributors continue to provide packages of g77-3.4 until we announce that `gfortran` fully replaces `g77`. The gfortran developers welcome any feedback on user experience with `gfortran` at `fortran@gcc.gnu.org`.

See section "GCC Command Options" in *Using the GNU Compiler Collection (GCC)*, for information on the non-Fortran-specific aspects of the `gcc` command (and, therefore, the `gfortran` command).

All `gcc` and `gfortran` options are accepted both by `gfortran` and by `gcc` (as well as any other drivers built at the same time, such as `g++`), since adding `gfortran` to the `gcc` distribution enables acceptance of `gfortran` options by all of the relevant drivers.

In some cases, options have positive and negative forms; the negative form of '`-ffoo`' would be '`-fno-foo`'. This manual documents only one of these two forms, whichever one is not the default.

4.1 Option Summary

Here is a summary of all the options specific to GNU Fortran, grouped by type. Explanations are in the following sections.

Fortran Language Options

See Section 4.2 [Options Controlling Fortran Dialect], page 26.

```
 -ffree-form -fno-fixed-form
-fdollar-ok -fimplicit-none -fmax-identifier-length
-std=std -ffixed-line-length-n -ffixed-line-length-none
-fdefault-double-8 -fdefault-integer-8 -fdefault-real-8
```

Warning Options

See Section 4.3 [Options to Request or Suppress Warnings], page 27.

```
 -fsyntax-only -pedantic -pedantic-errors
-w -Wall -Waliasing -Wconversion
-Wimplicit-interface -Wnonstd-intrinsics -Wsurprising -Wunderflow
-Wunused-labels -Wline-truncation -W
```

Debugging Options

See Section 4.4 [Options for Debugging Your Program or GCC], page 28.

```
-fdump-parse-tree
```

Directory Options

See Section 4.5 [Options for Directory Search], page 28.

```
-Idir -Mdir
```

Code Generation Options

See Section 4.6 [Options for Code Generation Conventions], page 29.

```
 -fno-automatic -ff2c -fno-underscoring -fsecond-underscore
-fbounds-check -fmax-stack-var-size=n
-fpackderived -frepack-arrays
```

4.2 Options Controlling Fortran Dialect

The following options control the dialect of Fortran that the compiler accepts:

`-ffree-form`
`-ffixed-form`
: Specify the layout used by the the source file. The free form layout was introduced in Fortran 90. Fixed form was traditionally used in older Fortran programs.

`-fdefault-double-8`
: Set the "DOUBLE PRECISION" type to an 8 byte wide.

`-fdefault-integer-8`
: Set the default integer and logical types to an 8 byte wide type. Do nothing if this is already the default.

`-fdefault-real-8`
: Set the default real type to an 8 byte wide type. Do nothing if this is already the default.

`-fdollar-ok`
: Allow '`$`' as a valid character in a symbol name.

`-fno-backslash`
: Compile switch to change the interpretation of a backslash from "C"-style escape characters to a single backslash character.

`-ffixed-line-length-`*n*
: Set column after which characters are ignored in typical fixed-form lines in the source file, and through which spaces are assumed (as if padded to that length) after the ends of short fixed-form lines.

  Popular values for *n* include 72 (the standard and the default), 80 (card image), and 132 (corresponds to "extended-source" options in some popular compilers). *n* may be '`none`', meaning that the entire line is meaningful and that continued character constants never have implicit spaces appended to them to fill out the line. '`-ffixed-line-length-0`' means the same thing as '`-ffixed-line-length-none`'.

`-fmax-identifier-length=`*n*
: Specify the maximum allowed identifier length. Typical values are 31 (Fortran 95) and 63 (Fortran 200x).

`-fimplicit-none`
: Specify that no implicit typing is allowed, unless overridden by explicit '`IMPLICIT`' statements. This is the equivalent of adding '`implicit none`' to the start of every procedure.

`-std=`*std*
: Conform to the specified standard. Allowed values for *std* are '`gnu`', '`f95`', '`f2003`' and '`legacy`'.

4.3 Options to Request or Suppress Warnings

Warnings are diagnostic messages that report constructions which are not inherently erroneous but which are risky or suggest there might have been an error.

You can request many specific warnings with options beginning '-W', for example '-Wimplicit' to request warnings on implicit declarations. Each of these specific warning options also has a negative form beginning '-Wno-' to turn off warnings; for example, '-Wno-implicit'. This manual lists only one of the two forms, whichever is not the default.

These options control the amount and kinds of warnings produced by GNU Fortran:

`-fsyntax-only`
: Check the code for syntax errors, but don't do anything beyond that.

`-pedantic`
: Issue warnings for uses of extensions to FORTRAN 95. '-pedantic' also applies to C-language constructs where they occur in GNU Fortran source files, such as use of '\e' in a character constant within a directive like '#include'.

  Valid FORTRAN 95 programs should compile properly with or without this option. However, without this option, certain GNU extensions and traditional Fortran features are supported as well. With this option, many of them are rejected.

  Some users try to use '-pedantic' to check programs for conformance. They soon find that it does not do quite what they want—it finds some nonstandard practices, but not all. However, improvements to gfortran in this area are welcome.

  This should be used in conjunction with -std=*std*.

`-pedantic-errors`
: Like '-pedantic', except that errors are produced rather than warnings.

`-w`
: Inhibit all warning messages.

`-Wall`
: Enables commonly used warning options that which pertain to usage that we recommend avoiding and that we believe is easy to avoid. This currently includes '-Wunused-labels', '-Waliasing', '-Wsurprising', '-Wnonstd-intrinsic' and '-Wline-truncation'.

`-Waliasing`
: Warn about possible aliasing of dummy arguments. The following example will trigger the warning as it would be illegal to bar to modify either parameter.

```
INTEGER A
CALL BAR(A,A)
```

`-Wconversion`
: Warn about implicit conversions between different types.

`-Wimplicit-interface`
: Warn about when procedure are called without an explicit interface. Note this only checks that an explicit interface is present. It does not check that the declared interfaces are consistent across program units.

`-Wnonstd-intrinsic`
: Warn if the user tries to use an intrinsic that does not belong to the standard the user has chosen via the -std option.

`-Wsurprising`
: Produce a warning when "suspicious" code constructs are encountered. While technically legal these usually indicate that an error has been made.

  This currently produces a warning under the following circumstances:

  - An INTEGER SELECT construct has a CASE that can never be matched as its lower value is greater than its upper value.
  - A LOGICAL SELECT construct has three CASE statements.

`-Wunderflow`
: Produce a warning when numerical constant expressions are encountered, which yield an UNDERFLOW during compilation.

`-Wunused-labels`
: Warn whenever a label is defined but never referenced.

`-Werror`
: Turns all warnings into errors.

`-W`
: Turns on "extra warnings" and, if optimization is specified via '`-O`', the '`-Wuninitialized`' option. (This might change in future versions of `gfortran`

See section "Options to Request or Suppress Warnings" in *Using the GNU Compiler Collection (GCC)*, for information on more options offered by the GBE shared by `gfortran`, `gcc` and other GNU compilers.

Some of these have no effect when compiling programs written in Fortran.

4.4 Options for Debugging Your Program or GNU Fortran

GNU Fortran has various special options that are used for debugging either your program or `gfortran`

`-fdump-parse-tree`
: Output the internal parse tree before starting code generation. Only really useful for debugging gfortran itself.

See section "Options for Debugging Your Program or GCC" in *Using the GNU Compiler Collection (GCC)*, for more information on debugging options.

4.5 Options for Directory Search

There options affect how affect how `gfortran` searches for files specified via the `INCLUDE` directive, and where it searches for previously compiled modules.

It also affects the search paths used by `cpp` when used to preprocess Fortran source.

`-I`*`dir`*
: These affect interpretation of the `INCLUDE` directive (as well as of the `#include` directive of the `cpp` preprocessor).

  Also note that the general behavior of '`-I`' and `INCLUDE` is pretty much the same as of '`-I`' with `#include` in the `cpp` preprocessor, with regard to looking for '`header.gcc`' files and other such things.

This path is also used to search for '.mod' files when previously compiled modules are required by a USE statement.

See section "Options for Directory Search" in *Using the GNU Compiler Collection (GCC)*, for information on the '-I' option.

-M*dir*

-J*dir* This option specifies where to put '.mod' files for compiled modules. It is also added to the list of directories to searched by an USE statement.

The default is the current directory.

'-J' is an alias for '-M' to avoid conflicts with existing GCC options.

4.6 Options for Code Generation Conventions

These machine-independent options control the interface conventions used in code generation.

Most of them have both positive and negative forms; the negative form of '-ffoo' would be '-fno-foo'. In the table below, only one of the forms is listed—the one which is not the default. You can figure out the other form by either removing 'no-' or adding it.

-fno-automatic

Treat each program unit as if the SAVE statement was specified for every local variable and array referenced in it. Does not affect common blocks. (Some Fortran compilers provide this option under the name '-static'.)

-ff2c Generate code designed to be compatible with code generated by g77 and f2c.

The calling conventions used by g77 (originally implemented in f2c) require functions that return type default REAL to actually return the C type double, and functions that return type COMPLEX to return the values via an extra argument in the calling sequence that points to where to store the return value. Under the default GNU calling conventions, such functions simply return their results as they would in GNU C – default REAL functions return the C type float, and COMPLEX functions return the GNU C type complex. Additionally, this option implies the '-fsecond-underscore' option, unless '-fno-second-underscore' is explicitly requested.

This does not affect the generation of code that interfaces with the libgfortran library.

Caution: It is not a good idea to mix Fortran code compiled with -ff2c with code compiled with the default -fno-f2c calling conventions as, calling COMPLEX or default REAL functions between program parts which were compiled with different calling conventions will break at execution time.

Caution: This will break code which passes intrinsic functions of type default REAL or COMPLEX as actual arguments, as the library implementations use the -fno-f2c calling conventions.

-fno-underscoring

Do not transform names of entities specified in the Fortran source file by appending underscores to them.

With '-funderscoring' in effect, gfortran appends one underscore to external names with no underscores.

This is done to ensure compatibility with code produced by many UNIX Fortran compilers.

Caution: The default behavior of gfortran is incompatible with f2c and g77, please use the '-ff2c' option if you want object files compiled with 'gfortran' to be compatible with object code created with these tools.

Use of '-fno-underscoring' is not recommended unless you are experimenting with issues such as integration of (GNU) Fortran into existing system environments (vis-a-vis existing libraries, tools, and so on).

For example, with '-funderscoring', and assuming other defaults like '-fcase-lower' and that 'j()' and 'max_count()' are external functions while 'my_var' and 'lvar' are local variables, a statement like

```
I = J() + MAX_COUNT (MY_VAR, LVAR)
```

is implemented as something akin to:

```
i = j_() + max_count__(&my_var__, &lvar);
```

With '-fno-underscoring', the same statement is implemented as:

```
i = j() + max_count(&my_var, &lvar);
```

Use of '-fno-underscoring' allows direct specification of user-defined names while debugging and when interfacing gfortran code with other languages.

Note that just because the names match does *not* mean that the interface implemented by gfortran for an external name matches the interface implemented by some other language for that same name. That is, getting code produced by gfortran to link to code produced by some other compiler using this or any other method can be only a small part of the overall solution—getting the code generated by both compilers to agree on issues other than naming can require significant effort, and, unlike naming disagreements, linkers normally cannot detect disagreements in these other areas.

Also, note that with '-fno-underscoring', the lack of appended underscores introduces the very real possibility that a user-defined external name will conflict with a name in a system library, which could make finding unresolved-reference bugs quite difficult in some cases—they might occur at program run time, and show up only as buggy behavior at run time.

In future versions of gfortran we hope to improve naming and linking issues so that debugging always involves using the names as they appear in the source, even if the names as seen by the linker are mangled to prevent accidental linking between procedures with incompatible interfaces.

-fsecond-underscore

By default, gfortran appends an underscore to external names. If this option is used gfortran appends two underscores to names with underscores and one underscore to external names with no underscores. (gfortran also appends two underscores to internal names with underscores to avoid naming collisions with external names.

This option has no effect if '-fno-underscoring' is in effect. It is implied by the '-ff2c' option.

Otherwise, with this option, an external name such as 'MAX_COUNT' is implemented as a reference to the link-time external symbol 'max_count__', instead of 'max_count_'. This is required for compatibility with g77 and f2c, and is implied by use of the '-ff2c' option.

-fbounds-check
: Enable generation of run-time checks for array subscripts and against the declared minimum and maximum values. It also checks array indices for assumed and deferred shape arrays against the actual allocated bounds.

  In the future this may also include other forms of checking, eg. checking substring references.

-fmax-stack-var-size=*n*
: This option specifies the size in bytes of the largest array that will be put on the stack.

  This option currently only affects local arrays declared with constant bounds, and may not apply to all character variables. Future versions of gfortran may improve this behavior.

  The default value for *n* is 32768.

-fpackderived
: This option tells gfortran to pack derived type members as closely as possible. Code compiled with this option is likely to be incompatible with code compiled without this option, and may execute slower.

-frepack-arrays
: In some circumstances gfortran may pass assumed shape array sections via a descriptor describing a discontiguous area of memory. This option adds code to the function prologue to repack the data into a contiguous block at runtime.

  This should result in faster accesses to the array. However it can introduce significant overhead to the function call, especially when the passed data is discontiguous.

See section "Options for Code Generation Conventions" in *Using the GNU Compiler Collection (GCC)*, for information on more options offered by the GBE shared by gfortran gcc and other GNU compilers.

4.7 Environment Variables Affecting GNU Fortran

GNU Fortran 95 currently does not make use of any environment variables to control its operation above and beyond those that affect the operation of gcc.

See section "Environment Variables Affecting GCC" in *Using the GNU Compiler Collection (GCC)*, for information on environment variables.

5 Project Status

> As soon as gfortran can parse all of the statements correctly, it will be in the "larva" state. When we generate code, the "puppa" state. When gfortran is done, we'll see if it will be a beautiful butterfly, or just a big bug....
>
> –Andy Vaught, April 2000

The start of the GNU Fortran 95 project was announced on the GCC homepage in March 18, 2000 (even though Andy had already been working on it for a while, or course).

Gfortran is currently reaching the stage where is is able to compile real world programs. However it is still under development and has many rough edges.

5.1 Compiler Status

Front end This is the part of gfortran which parses a source file, verifies that it is valid Fortran 95, performs compile time replacement of constants (PARAMETER variables) and reads and generate module files. This is almost complete. Every Fortran 95 source should be accepted, and most none-Fortran 95 source should be rejected. If you find a source file where this is not true, please tell us. You can use the -fsyntax-only switch to make gfortran quit after running the front end, effectively reducing it to a syntax checker.

Middle end interface
These are the parts of gfortran that take the parse tree generated by the front end and translate it to the GENERIC form required by the GCC back end. Work is ongoing in these parts of gfortran, but a large part has already been completed.

5.2 Library Status

Some intrinsic functions map directly to library functions, and in most cases the name of the library function used depends on the type of the arguments. For some intrinsics we generate inline code, and for others, such as sin, cos and sqrt, we rely on the backend to use special instructions in the floating point unit of the CPU if available, or to fall back to a call to libm if these are not available.

Implementation of some non-elemental intrinsic functions (eg. DOT_PRODUCT, AVERAGE) is not yet optimal. This is hard because we have to make decisions whether to use inline code (good for small arrays as no function call overhead occurs) or generate function calls (good for large arrays as it allows use of hand-optimized assembly routines, SIMD instructions, etc.)

The IO library is still under development. The following features should be usable for real programs:

- List directed
- Unformatted sequential

Usable with bugs:

- Formatted sequential ('T' edit descriptor, and others)

Not recommended:

- Unformatted direct access
- Formatted direct access

Many Fortran programs only use a small subset of the available IO capabilities, so your mileage may vary.

5.3 Proposed Extensions

Here's a list of proposed extensions for `gfortran`, in no particular order. Most of these are necessary to be fully compatible with existing Fortran compilers, but they are not part of the official J3 Fortran 95 standard.

5.3.1 Compiler extensions:

- Flag for defining the kind number for default logicals.
- User-specified alignment rules for structures.
- Flag to generate a `Makefile` info.
- Automatically extend single precision constants to double.
- Cray pointers (this was high on the `g77` wishlist).
- Compile code that conserves memory by dynamically allocating common and module storage either on stack or heap.
- Flag to cause the compiler to distinguish between upper and lower case names. The Fortran 95 standard does not distinguish them.
- Compile flag to generate code for array conformance checking (suggest -CC).
- User control of symbol names (underscores, etc).
- Compile setting for maximum size of stack frame size before spilling parts to static or heap.
- Flag to force local variables into static space.
- Flag to force local variables onto stack.
- Flag to compile lines beginning with "D".
- Flag to ignore lines beginning with "D".
- Flag for maximum errors before ending compile.
- Generate code to check for null pointer dereferences – prints locus of dereference instead of segfaulting. There was some discussion about this option in the g95 development mailing list.
- Allow setting default unit number.
- Option to initialize of otherwise uninitialized integer and floating point variables.
- Support for OpenMP directives. This also requires support from the runtime library and the rest of the compiler.
- Support for Fortran 200x. This includes several new features including floating point exceptions, extended use of allocatable arrays, C interoperability, Parameterizer data types and function pointers.

5.3.2 Environment Options

- Pluggable library modules for random numbers, linear algebra. LA should use BLAS calling conventions.
- Environment variables controlling actions on arithmetic exceptions like overflow, underflow, precision loss – Generate NaN, abort, default. action.
- Set precision for fp units that support it (i387).
- Variables for setting fp rounding mode.
- Variable to fill uninitialized variables with a user-defined bit pattern.
- Environment variable controlling filename that is opened for that unit number.
- Environment variable to clear/trash memory being freed.
- Environment variable to control tracing of allocations and frees.
- Environment variable to display allocated memory at normal program end.
- Environment variable for filename for * IO-unit.
- Environment variable for temporary file directory.
- Environment variable forcing standard output to be line buffered (unix).
- Variable for swapping endianness during unformatted read.
- Variable for swapping Endianness during unformatted write.

6 Extensions

gfortran implements a number of extensions over standard Fortran. This chapter contains information on their syntax and meaning. There are currently two categories of gfortran extensions, those that provide functionality beyond that provided by any standard, and those that are supported by gfortran purely for backward compatibility with legacy compilers. By default, '-std=gnu' allows the compiler to accept both types of extensions, but to warn about the use of the latter. Specifying either '-std=f95' or '-std=f2003' disables both types of extensions, and '-std=legacy' allows both without warning.

6.1 Old-style kind specifications

gfortran allows old-style kind specifications in declarations. These look like:

```
          TYPESPEC*k x,y,z
```

where TYPESPEC is a basic type, and where k is a valid kind number for that type. The statement then declares x, y and z to be of type TYPESPEC with kind k. In other words, it is equivalent to the standard conforming declaration

```
          TYPESPEC(k) x,y,z
```

6.2 Old-style variable initialization

gfortran allows old-style initialization of variables of the form:

```
          INTEGER*4 i/1/,j/2/
          REAL*8 x(2,2) /3*0.,1./
```

These are only allowed in declarations without double colons (::), as these were introduced in Fortran 90 which also introduced a new syntax for variable initializations. The syntax for the individual initializers is as for the DATA statement, but unlike in a DATA statement, an initializer only applies to the variable immediately preceding. In other words, something like INTEGER I,J/2,3/ is not valid.

Examples of standard conforming code equivalent to the above example, are:

```
! Fortran 90
      INTEGER(4) :: i = 1, j = 2
      REAL(8) :: x(2,2) = RESHAPE((/0.,0.,0.,1./),SHAPE(x))
! Fortran 77
      INTEGER  i, j
      DOUBLE PRECISION x(2,2)
      DATA i,j,x /1,2,3*0.,1./
```

6.3 Extensions to namelist

gfortran fully supports the fortran95 standard for namelist io including array qualifiers, substrings and fully qualified derived types. The output from a namelist write is compatible with namelist read. The output has all names in upper case and indentation to column 1 after the namelist name. Two extensions are permitted:

Old-style use of $ instead of &

```
$MYNML
 X(:)%Y(2) = 1.0 2.0 3.0
 CH(1:4) = "abcd"
$END
```

It should be noticed that the default terminator is / rather than &END.

Querying of the namelist when inputting from stdin. After at least one space, entering ? sends to stdout the namelist name and the names of the variables in the namelist:

```
?

&mynml
 x
 x%y
 ch
&end
```

Entering =? outputs the namelist to stdout, as if WRITE (*,NML = mynml) had been called:

```
=?

&MYNML
 X(1)%Y=  0.000000    ,  1.000000    ,  0.000000    ,
 X(2)%Y=  0.000000    ,  2.000000    ,  0.000000    ,
 X(3)%Y=  0.000000    ,  3.000000    ,  0.000000    ,
 CH=abcd,  /
```

To aid this dialog, when input is from stdin, errors produce send their messages to stderr and execution continues, even if IOSTAT is set.

PRINT namelist is permitted. This causes an error if -std=f95 is used.

```
PROGRAM test_print
  REAL, dimension (4)  ::  x = (/1.0, 2.0, 3.0, 4.0/)
  NAMELIST /mynml/ x
  PRINT mynml
END PROGRAM test_print
```

6.4 Implicitly interconvert LOGICAL and INTEGER

As a GNU extension for backwards compatability with other compilers, `gfortran` allows the implicit conversion of LOGICALs to INTEGERs and vice versa. When converting from a LOGICAL to an INTEGER, the numeric value of `.FALSE.` is zero, and that of `.TRUE.` is one. When converting from INTEGER to LOGICAL, the value zero is interpreted as `.FALSE.` and any non-zero value is interpreted as `.TRUE.`.

```
        INTEGER*4 i
        i = .FALSE.
```

6.5 Hollerith constants support

A Hollerith constant is a string of characters preceded by the letter ‘`H`’ or ‘`h`’, and there must be an literal, unsigned, nonzero default integer constant indicating the number of characters in the string. Hollerith constants are stored as byte strings, one character per byte.

`gfortran` supports Hollerith constants. They can be used as the right hands in the `DATA` statement and `ASSIGN` statement, also as the arguments. The left hands can be of Integer, Real, Complex and Logical type. The constant will be padded or trancated to fit the size of left hand.

Valid Hollerith constants examples:

```
complex*16 x(2)
data x /16Habcdefghijklmnop, 16Hqrstuvwxyz012345/
call foo (4H abc)
x(1) = 16Habcdefghijklmnop
```

Invalid Hollerith constants examples:

```
integer*4 a
a = 8H12345678 ! The Hollerith constant is too long. It will be truncated.
a = 0H         ! At least one character needed.
```

7 Intrinsic Procedures

This portion of the document is incomplete and undergoing massive expansion and editing. All contributions and corrections are strongly encouraged.

7.1 Introduction to intrinsic procedures

Gfortran provides a rich set of intrinsic procedures that includes all the intrinsic procedures required by the Fortran 95 standard, a set of intrinsic procedures for backwards compatibility with Gnu Fortran 77 (i.e., `g77`), and a small selection of intrinsic procedures from the Fortran 2003 standard. Any description here, which conflicts with a description in either the Fortran 95 standard or the Fortran 2003 standard, is unintentional and the standard(s) should be considered authoritative.

The enumeration of the `KIND` type parameter is processor defined in the Fortran 95 standard. Gfortran defines the default integer type and default real type by `INTEGER(KIND=4)` and `REAL(KIND=4)`, respectively. The standard mandates that both data types shall have another kind, which have more precision. On typical target architectures supported by `gfortran`, this kind type parameter is `KIND=8`. Hence, `REAL(KIND=8)` and `DOUBLE PRECISION` are equivalent. In the description of generic intrinsic procedures, the kind type parameter will be specified by `KIND=*`, and in the description of specific names for an intrinsic procedure the kind type parameter will be explicitly given (e.g., `REAL(KIND=4)` or `REAL(KIND=8)`). Finally, for brevity the optional `KIND=` syntax will be omitted.

Many of the intrinsics procedures take one or more optional arguments. This document follows the convention used in the Fortran 95 standard, and denotes such arguments by square brackets.

`Gfortran` offers the '`-std=f95`' and '`-std=gnu`' options, which can be used to restrict the set of intrinsic procedures to a given standard. By default, `gfortran` sets the '`-std=gnu`' option, and so all intrinsic procedures described here are accepted. There is one caveat. For a select group of intrinsic procedures, `g77` implemented both a function and a subroutine. Both classes have been implemented in `gfortran` for backwards compatibility with `g77`. It is noted here that these functions and subroutines cannot be intermixed in a given subprogram. In the descriptions that follow, the applicable option(s) is noted.

7.2 `ABORT` — Abort the program

Description:
: `ABORT` causes immediate termination of the program. On operating systems that support a core dump, `ABORT` will produce a core dump, which is suitable for debugging purposes.

Option: gnu

Class: non-elemental subroutine

Syntax: `CALL ABORT`

Return value:
: Does not return.

Example:

```
program test_abort
  integer :: i = 1, j = 2
  if (i /= j) call abort
end program test_abort
```

7.3 ABS — Absolute value

Description:
`ABS(X)` computes the absolute value of `X`.

Option: f95, gnu

Class: elemental function

Syntax: `X = ABS(X)`

Arguments:

X The type of the argument shall be an `INTEGER(*)`, `REAL(*)`, or `COMPLEX(*)`.

Return value:
The return value is of the same type and kind as the argument except the return value is `REAL(*)` for a `COMPLEX(*)` argument.

Example:

```
program test_abs
  integer :: i = -1
  real :: x = -1.e0
  complex :: z = (-1.e0,0.e0)
  i = abs(i)
  x = abs(x)
  x = abs(z)
end program test_abs
```

Specific names:

Name	Argument	Return type	Option
`CABS(Z)`	`COMPLEX(4) Z`	`REAL(4)`	f95, gnu
`DABS(X)`	`REAL(8) X`	`REAL(8)`	f95, gnu
`IABS(I)`	`INTEGER(4) I`	`INTEGER(4)`	f95, gnu
`ZABS(Z)`	`COMPLEX(8) Z`	`COMPLEX(8)`	gnu
`CDABS(Z)`	`COMPLEX(8) Z`	`COMPLEX(8)`	gnu

7.4 ACHAR — Character in ASCII collating sequence

Description:
`ACHAR(I)` returns the character located at position `I` in the ASCII collating sequence.

Option: f95, gnu

Class: elemental function

Syntax: `C = ACHAR(I)`

Arguments:

I	The type shall be INTEGER(*).

Return value:
The return value is of type CHARACTER with a length of one. The kind type parameter is the same as KIND('A').

Example:

```
program test_achar
  character c
  c = achar(32)
end program test_achar
```

7.5 ACOS — Arc cosine function

Description:
ACOS(X) computes the arc cosine of *X*.

Option: f95, gnu

Class: elemental function

Syntax: X = ACOS(X)

Arguments:

X	The type shall be REAL(*) with a magnitude that is less than one.

Return value:
The return value is of type REAL(*) and it lies in the range $0 \leq \arccos(x) \leq \pi$. The kind type parameter is the same as *X*.

Example:

```
program test_acos
  real(8) :: x = 0.866_8
  x = achar(x)
end program test_acos
```

Specific names:

Name	Argument	Return type	Option
DACOS(X)	REAL(8) X	REAL(8)	f95, gnu

7.6 ADJUSTL — Left adjust a string

Description:
ADJUSTL(STR) will left adjust a string by removing leading spaces. Spaces are inserted at the end of the string as needed.

Option: f95, gnu

Class: elemental function

Syntax: STR = ADJUSTL(STR)

Arguments:

STR	The type shall be CHARACTER.

Return value:
The return value is of type CHARACTER where leading spaces are removed and the same number of spaces are inserted on the end of *STR*.

Example:

```
program test_adjustl
  character(len=20) :: str = '   gfortran'
  str = adjustl(str)
  print *, str
end program test_adjustl
```

7.7 ADJUSTR — Right adjust a string

Description:
ADJUSTR(STR) will right adjust a string by removing trailing spaces. Spaces are inserted at the start of the string as needed.

Option: f95, gnu

Class: elemental function

Syntax: STR = ADJUSTR(STR)

Arguments:

STR	The type shall be CHARACTER.

Return value:
The return value is of type CHARACTER where trailing spaces are removed and the same number of spaces are inserted at the start of *STR*.

Example:

```
program test_adjustr
  character(len=20) :: str = 'gfortran'
  str = adjustr(str)
  print *, str
end program test_adjustr
```

7.8 AIMAG — Imaginary part of complex number

Description:
AIMAG(Z) yields the imaginary part of complex argument Z.

Option: f95, gnu

Class: elemental function

Syntax: X = AIMAG(Z)

Arguments:

Z	The type of the argument shall be COMPLEX(*).

Return value:
The return value is of type real with the kind type parameter of the argument.

Example:

```
program test_aimag
  complex(4) z4
  complex(8) z8
  z4 = cmplx(1.e0_4, 0.e0_4)
  z8 = cmplx(0.e0_8, 1.e0_8)
  print *, aimag(z4), dimag(z8)
end program test_aimag
```

Specific names:

Name	Argument	Return type	Option
`DIMAG(Z)`	`COMPLEX(8) Z`	`REAL(8)`	f95, gnu

7.9 `AINT` — Imaginary part of complex number

Description:
`AINT(X [, KIND])` truncates its argument to a whole number.

Option: f95, gnu

Class: elemental function

Syntax: `X = AINT(X) X = AINT(X, KIND)`

Arguments:

X	The type of the argument shall be `REAL(*)`.
KIND	(Optional) *KIND* shall be a scalar integer initialization expression.

Return value:
The return value is of type real with the kind type parameter of the argument if the optional *KIND* is absent; otherwise, the kind type parameter will be given by *KIND*. If the magnitude of *X* is less than one, then `AINT(X)` returns zero. If the magnitude is equal to or greater than one, then it returns the largest whole number that does not exceed its magnitude. The sign is the same as the sign of *X*.

Example:

```
program test_aint
  real(4) x4
  real(8) x8
  x4 = 1.234E0_4
  x8 = 4.321_8
  print *, aint(x4), dint(x8)
  x8 = aint(x4,8)
end program test_aint
```

Specific names:

Name	Argument	Return type	Option
`DINT(X)`	`REAL(8) X`	`REAL(8)`	f95, gnu

7.10 `ALL` — All values in *MASK* along *DIM* are true

Description:
`ALL(MASK [, DIM])` determines if all the values are true in *MASK* in the array along dimension *DIM*.

Option: f95, gnu

Class: transformational function

Syntax: `L = ALL(MASK) L = ALL(MASK, DIM)`

Arguments:

MASK The type of the argument shall be `LOGICAL(*)` and it shall not be scalar.

DIM (Optional) *DIM* shall be a scalar integer with a value that lies between one and the rank of *MASK*.

Return value:

`ALL(MASK)` returns a scalar value of type `LOGICAL(*)` where the kind type parameter is the same as the kind type parameter of *MASK*. If *DIM* is present, then `ALL(MASK, DIM)` returns an array with the rank of *MASK* minus 1. The shape is determined from the shape of *MASK* where the *DIM* dimension is elided.

(A) `ALL(MASK)` is true if all elements of *MASK* are true. It also is true if *MASK* has zero size; otherwise, it is false.

(B) If the rank of *MASK* is one, then `ALL(MASK,DIM)` is equivalent to `ALL(MASK)`. If the rank is greater than one, then `ALL(MASK,DIM)` is determined by applying `ALL` to the array sections.

Example:

```
program test_all
  logical l
  l = all((/.true., .true., .true./))
  print *, l
  call section
  contains
    subroutine section
      integer a(2,3), b(2,3)
      a = 1
      b = 1
      b(2,2) = 2
      print *, all(a .eq. b, 1)
      print *, all(a .eq. b, 2)
    end subroutine section
end program test_all
```

7.11 `ALLOCATED` — Status of an allocatable entity

Description:

`ALLOCATED(X)` checks the status of whether *X* is allocated.

Option: f95, gnu

Class: inquiry function

Syntax: `L = ALLOCATED(X)`

Arguments:

X The argument shall be an `ALLOCATABLE` array.

Return value:
The return value is a scalar `LOGICAL` with the default logical kind type parameter. If *X* is allocated, `ALLOCATED(X)` is `.TRUE.`; otherwise, it returns the `.TRUE.`

Example:
```
program test_allocated
  integer :: i = 4
  real(4), allocatable :: x(:)
  if (allocated(x) .eqv. .false.) allocate(x(i)
end program test_allocated
```

7.12 `ANINT` — Imaginary part of complex number

Description:
`ANINT(X [, KIND])` rounds its argument to the nearest whole number.

Option: f95, gnu

Class: elemental function

Syntax: `X = ANINT(X) X = ANINT(X, KIND)`

Arguments:

X	The type of the argument shall be `REAL(*)`.
KIND	(Optional) *KIND* shall be a scalar integer initialization expression.

Return value:
The return value is of type real with the kind type parameter of the argument if the optional *KIND* is absent; otherwise, the kind type parameter will be given by *KIND*. If *X* is greater than zero, then `ANINT(X)` returns `AINT(X+0.5)`. If *X* is less than or equal to zero, then return `AINT(X-0.5)`.

Example:
```
program test_anint
  real(4) x4
  real(8) x8
  x4 = 1.234E0_4
  x8 = 4.321_8
  print *, anint(x4), dnint(x8)
  x8 = anint(x4,8)
end program test_anint
```

Specific names:

Name	Argument	Return type	Option
`DNINT(X)`	`REAL(8) X`	`REAL(8)`	f95, gnu

7.13 `ANY` — Any value in *MASK* along *DIM* is true

Description:
`ANY(MASK [, DIM])` determines if any of the values in the logical array *MASK* along dimension *DIM* are `.TRUE.`.

Option: f95, gnu

Class: transformational function

Syntax: `L = ANY(MASK) L = ANY(MASK, DIM)`

Arguments:

MASK The type of the argument shall be `LOGICAL(*)` and it shall not be scalar.

DIM (Optional) *DIM* shall be a scalar integer with a value that lies between one and the rank of *MASK*.

Return value:

`ANY(MASK)` returns a scalar value of type `LOGICAL(*)` where the kind type parameter is the same as the kind type parameter of *MASK*. If *DIM* is present, then `ANY(MASK, DIM)` returns an array with the rank of *MASK* minus 1. The shape is determined from the shape of *MASK* where the *DIM* dimension is elided.

(A) `ANY(MASK)` is true if any element of *MASK* is true; otherwise, it is false. It also is false if *MASK* has zero size.

(B) If the rank of *MASK* is one, then `ANY(MASK,DIM)` is equivalent to `ANY(MASK)`. If the rank is greater than one, then `ANY(MASK,DIM)` is determined by applying `ANY` to the array sections.

Example:

```
program test_any
  logical l
  l = any((/.true., .true., .true./))
  print *, l
  call section
  contains
    subroutine section
      integer a(2,3), b(2,3)
      a = 1
      b = 1
      b(2,2) = 2
      print *, any(a .eq. b, 1)
      print *, any(a .eq. b, 2)
    end subroutine section
end program test_any
```

7.14 `ASIN` — Arcsine function

Description:

`ASIN(X)` computes the arcsine of its *X*.

Option: f95, gnu

Class: elemental function

Syntax: `X = ASIN(X)`

Arguments:

X The type shall be `REAL(*)`, and a magnitude that is less than one.

Return value:

The return value is of type `REAL(*)` and it lies in the range $-\pi/2 \leq \arccos(x) \leq \pi/2$. The kind type parameter is the same as *X*.

Example:

```
program test_asin
  real(8) :: x = 0.866_8
  x = asin(x)
end program test_asin
```

Specific names:

Name	Argument	Return type	Option
`DASIN(X)`	`REAL(8) X`	`REAL(8)`	f95, gnu

7.15 `ASSOCIATED` — Status of a pointer or pointer/target pair

Description:
`ASSOCIATED(PTR [, TGT])` determines the status of the pointer *PTR* or if *PTR* is associated with the target *TGT*.

Option: f95, gnu

Class: inquiry function

Syntax: `L = ASSOCIATED(PTR) L = ASSOCIATED(PTR [, TGT])`

Arguments:

PTR	*PTR* shall have the `POINTER` attribute and it can be of any type.
TGT	(Optional) *TGT* shall be a `POINTER` or a `TARGET`. It must have the same type, kind type parameter, and array rank as *PTR*.

The status of neither *PTR* nor *TGT* can be undefined.

Return value:
`ASSOCIATED(PTR)` returns a scalar value of type `LOGICAL(4)`. There are several cases:

(A) If the optional *TGT* is not present, then `ASSOCIATED(PTR)`
is true if *PTR* is associated with a target; otherwise, it returns false.

(B) If *TGT* is present and a scalar target, the result is true if
TGT is not a 0 sized storage sequence and the target associated with *PTR* occupies the same storage units. If *PTR* is disassociated, then the result is false.

(C) If *TGT* is present and an array target, the result is true if
TGT and *PTR* have the same shape, are not 0 sized arrays, are arrays whose elements are not 0 sized storage sequences, and *TGT* and *PTR* occupy the same storage units in array element order. As in case(B), the result is false, if *PTR* is disassociated.

(D) If *TGT* is present and an scalar pointer, the result is true if
target associated with *PTR* and the target associated with *TGT* are not 0 sized storage sequences and occupy the same storage units. The result is false, if either *TGT* or *PTR* is disassociated.

(E) If *TGT* is present and an array pointer, the result is true if
target associated with *PTR* and the target associated with *TGT* have the same shape, are not 0 sized arrays, are arrays whose elements are not 0 sized storage sequences, and *TGT* and *PTR* occupy

the same storage units in array element order. The result is false, if either *TGT* or *PTR* is disassociated.

Example:

```
program test_associated
   implicit none
   real, target  :: tgt(2) = (/1., 2./)
   real, pointer :: ptr(:)
   ptr => tgt
   if (associated(ptr)     .eqv. .false.) call abort
   if (associated(ptr,tgt) .eqv. .false.) call abort
end program test_associated
```

7.16 `ATAN` — Arctangent function

Description:
`ATAN(X)` computes the arctangent of *X*.

Option: f95, gnu

Class: elemental function

Syntax: `X = ATAN(X)`

Arguments:

X	The type shall be `REAL(*)`.

Return value:
The return value is of type `REAL(*)` and it lies in the range $-\pi/2 \leq \arcsin(x) \leq \pi/2$.

Example:

```
program test_atan
  real(8) :: x = 2.866_8
  x = atan(x)
end program test_atan
```

Specific names:

Name	Argument	Return type	Option
`DATAN(X)`	`REAL(8) X`	`REAL(8)`	f95, gnu

7.17 `ATAN2` — Arctangent function

Description:
`ATAN2(Y,X)` computes the arctangent of the complex number $X + iY$.

Option: f95, gnu

Class: elemental function

Syntax: `X = ATAN2(Y,X)`

Arguments:

Y	The type shall be `REAL(*)`.
X	The type and kind type parameter shall be the same as *Y*. If *Y* is zero, then *X* must be nonzero.

Return value:
The return value has the same type and kind type parameter as Y. It is the principle value of the complex number $X + iY$. If X is nonzero, then it lies in the range $-\pi \le \arccos(x) \le \pi$. The sign is positive if Y is positive. If Y is zero, then the return value is zero if X is positive and π if X is negative. Finally, if X is zero, then the magnitude of the result is $\pi/2$.

Example:

```
program test_atan2
  real(4) :: x = 1.e0_4, y = 0.5e0_4
  x = atan2(y,x)
end program test_atan2
```

Specific names:

Name	Argument	Return type	Option
DATAN2(X)	REAL(8) X	REAL(8)	f95, gnu

7.18 BESJ0 — Bessel function of the first kind of order 0

Description:
BESJ0(X) computes the Bessel function of the first kind of order 0 of X.

Option: gnu

Class: elemental function

Syntax: X = BESJ0(X)

Arguments:

X	The type shall be REAL(*), and it shall be scalar.

Return value:
The return value is of type REAL(*) and it lies in the range $-0.4027... \le Bessel(0,x) \le 1$.

Example:

```
program test_besj0
  real(8) :: x = 0.0_8
  x = besj0(x)
end program test_besj0
```

Specific names:

Name	Argument	Return type	Option
DBESJ0(X)	REAL(8) X	REAL(8)	gnu

7.19 BESJ1 — Bessel function of the first kind of order 1

Description:
BESJ1(X) computes the Bessel function of the first kind of order 1 of X.

Option: gnu

Class: elemental function

Syntax: X = BESJ1(X)

Arguments:

X	The type shall be `REAL(*)`, and it shall be scalar.

Return value:
The return value is of type `REAL(*)` and it lies in the range $-0.5818... \leq Bessel(0, x) \leq 0.5818$.

Example:

```
program test_besj1
  real(8) :: x = 1.0_8
  x = besj1(x)
end program test_besj1
```

Specific names:

Name	Argument	Return type	Option
`DBESJ1(X)`	`REAL(8) X`	`REAL(8)`	gnu

7.20 `BESJN` — Bessel function of the first kind

Description:
`BESJN(N, X)` computes the Bessel function of the first kind of order *N* of *X*.

Option: gnu

Class: elemental function

Syntax: `Y = BESJN(N, X)`

Arguments:

N	The type shall be `INTEGER(*)`, and it shall be scalar.
X	The type shall be `REAL(*)`, and it shall be scalar.

Return value:
The return value is a scalar of type `REAL(*)`.

Example:

```
program test_besjn
  real(8) :: x = 1.0_8
  x = besjn(5,x)
end program test_besjn
```

Specific names:

Name	Argument	Return type	Option
`DBESJN(X)`	`INTEGER(*) N` `REAL(8) X`	`REAL(8)`	gnu

7.21 `BESY0` — Bessel function of the second kind of order 0

Description:
`BESY0(X)` computes the Bessel function of the second kind of order 0 of *X*.

Option: gnu

Class: elemental function

Syntax: `X = BESY0(X)`

Arguments:

X	The type shall be `REAL(*)`, and it shall be scalar.

Return value:
The return value is a scalar of type `REAL(*)`.

Example:

```
program test_besy0
  real(8) :: x = 0.0_8
  x = besy0(x)
end program test_besy0
```

Specific names:

Name	Argument	Return type	Option
`DBESY0(X)`	`REAL(8) X`	`REAL(8)`	gnu

7.22 `BESY1` — Bessel function of the second kind of order 1

Description:
`BESY1(X)` computes the Bessel function of the second kind of order 1 of *X*.

Option: gnu

Class: elemental function

Syntax: `X = BESY1(X)`

Arguments:

X	The type shall be `REAL(*)`, and it shall be scalar.

Return value:
The return value is a scalar of type `REAL(*)`.

Example:

```
program test_besy1
  real(8) :: x = 1.0_8
  x = besy1(x)
end program test_besy1
```

Specific names:

Name	Argument	Return type	Option
`DBESY1(X)`	`REAL(8) X`	`REAL(8)`	gnu

7.23 `BESYN` — Bessel function of the second kind

Description:
`BESYN(N, X)` computes the Bessel function of the second kind of order *N* of *X*.

Option: gnu

Class: elemental function

Syntax: `Y = BESYN(N, X)`

Arguments:

N	The type shall be `INTEGER(*)`, and it shall be scalar.
X	The type shall be `REAL(*)`, and it shall be scalar.

Return value:
The return value is a scalar of type `REAL(*)`.

Example:

```
program test_besyn
  real(8) :: x = 1.0_8
  x = besyn(5,x)
end program test_besyn
```

Specific names:

Name	Argument	Return type	Option
`DBESYN(N,X)`	`INTEGER(*) N` `REAL(8) X`	`REAL(8)`	gnu

7.24 `BIT_SIZE` — Bit size inquiry function

Description:
`BIT_SIZE(I)` returns the number of bits (integer precision plus sign bit) represented by the type of *I*.

Option: f95, gnu

Class: elemental function

Syntax: `I = BIT_SIZE(I)`

Arguments:

I	The type shall be `INTEGER(*)`.

Return value:
The return value is of type `INTEGER(*)`

Example:

```
program test_bit_size
    integer :: i = 123
    integer :: size
    size = bit_size(i)
    print *, size
end program test_bit_size
```

7.25 `BTEST` — Bit test function

Description:
`BTEST(I,POS)` returns logical `.TRUE.` if the bit at *POS* in *I* is set.

Option: f95, gnu

Class: elemental function

Syntax: `I = BTEST(I,POS)`

Arguments:

I	The type shall be `INTEGER(*)`.
POS	The type shall be `INTEGER(*)`.

Return value:
The return value is of type `LOGICAL`

Example:

```
program test_btest
    integer :: i = 32768 + 1024 + 64
    integer :: pos
    logical :: bool
    do pos=0,16
        bool = btest(i, pos)
        print *, pos, bool
    end do
end program test_btest
```

7.26 CEILING — Integer ceiling function

Description:
`CEILING(X)` returns the least integer greater than or equal to *X*.

Option: f95, gnu

Class: elemental function

Syntax: `I = CEILING(X[,KIND])`

Arguments:

X	The type shall be `REAL(*)`.
KIND	Optional scaler integer initialization expression.

Return value:
The return value is of type `INTEGER(KIND)`

Example:

```
program test_ceiling
    real :: x = 63.29
    real :: y = -63.59
    print *, ceiling(x) ! returns 64
    print *, ceiling(y) ! returns -63
end program test_ceiling
```

7.27 CHAR — Character conversion function

Description:
`CHAR(I,[KIND])` returns the character represented by the integer *I*.

Option: f95, gnu

Class: elemental function

Syntax: `C = CHAR(I[,KIND])`

Arguments:

I	The type shall be `INTEGER(*)`.
KIND	Optional scaler integer initialization expression.

Return value:
The return value is of type `CHARACTER(1)`

Example:

```
program test_char
    integer :: i = 74
    character(1) :: c
    c = char(i)
    print *, i, c ! returns 'J'
end program test_char
```

7.28 CMPLX — Complex conversion function

Description:
`CMPLX(X,[Y,KIND])` returns a complex number where *X* is converted to the real component. If *Y* is present it is converted to the imaginary component. If *Y* is not present then the imaginary component is set to 0.0. If *X* is complex then *Y* must not be present.

Option: f95, gnu

Class: elemental function

Syntax: `C = CMPLX(X[,Y,KIND])`

Arguments:

X	The type may be `INTEGER(*)`, `REAL(*)`, or `COMPLEX(*)`.
Y	Optional, allowed if *X* is not `COMPLEX(*)`. May be `INTEGER(*)` or `REAL(*)`.
KIND	Optional scaler integer initialization expression.

Return value:
The return value is of type `COMPLEX(*)`

Example:

```
program test_cmplx
    integer :: i = 42
    real :: x = 3.14
    complex :: z
    z = cmplx(i, x)
    print *, z, cmplx(x)
end program test_cmplx
```

7.29 COMMAND_ARGUMENT_COUNT — Argument count function

Description:
`COMMAND_ARGUMENT_COUNT()` returns the number of arguments passed on the command line when the containing program was invoked.

Option: f2003, gnu

Class: non-elemental function

Syntax: `I = COMMAND_ARGUMENT_COUNT()`

Arguments:
None

Return value:
The return value is of type `INTEGER(4)`

Example:

```
program test_command_argument_count
    integer :: count
    count = command_argument_count()
    print *, count
end program test_command_argument_count
```

7.30 CONJG — Complex conjugate function

Description:
CONJG(Z) returns the conjugate of *Z*. If *Z* is (x, y) then the result is (x, -y)

Option: f95, gnu

Class: elemental function

Syntax: Z = CONJG(Z)

Arguments:

Z	The type shall be COMPLEX(*).

Return value:
The return value is of type COMPLEX(*).

Example:

```
program test_conjg
    complex :: z = (2.0, 3.0)
    complex(8) :: dz = (2.71_8, -3.14_8)
    z= conjg(z)
    print *, z
    dz = dconjg(dz)
    print *, dz
end program test_conjg
```

Specific names:

Name	Argument	Return type	Option
DCONJG(Z)	COMPLEX(8) Z	COMPLEX(8)	gnu

7.31 COS — Cosine function

Description:
COS(X) computes the cosine of *X*.

Option: f95, gnu

Class: elemental function

Syntax: X = COS(X)

Arguments:

X	The type shall be REAL(*) or COMPLEX(*).

Return value:
The return value has the same type and kind as *X*.

Example:

```
program test_cos
  real :: x = 0.0
  x = cos(x)
end program test_cos
```

Specific names:

Name	Argument	Return type	Option
DCOS(X)	REAL(8) X	REAL(8)	f95, gnu
CCOS(X)	COMPLEX(4) X	COMPLEX(4)	f95, gnu
ZCOS(X)	COMPLEX(8) X	COMPLEX(8)	f95, gnu
CDCOS(X)	COMPLEX(8) X	COMPLEX(8)	f95, gnu

7.32 COSH — Hyperbolic cosine function

Description:
COSH(X) computes the hyperbolic cosine of *X*.

Option: f95, gnu

Class: elemental function

Syntax: X = COSH(X)

Arguments:

X	The type shall be REAL(*).

Return value:
The return value is of type REAL(*) and it is positive ($\cosh(x) \geq 0$.

Example:

```
program test_cosh
  real(8) :: x = 1.0_8
  x = cosh(x)
end program test_cosh
```

Specific names:

Name	Argument	Return type	Option
DCOSH(X)	REAL(8) X	REAL(8)	f95, gnu

7.33 COUNT — Count function

Description:
COUNT(MASK[,DIM]) counts the number of .TRUE. elements of *MASK* along the dimension of *DIM*. If *DIM* is omitted it is taken to be 1. *DIM* is a scaler of type INTEGER in the range of $1/leqDIM/leqn)$ where n is the rank of *MASK*.

Option: f95, gnu

Class: transformational function

Syntax: I = COUNT(MASK[,DIM])

Arguments:

MASK	The type shall be LOGICAL.
DIM	The type shall be INTEGER.

Return value:
The return value is of type `INTEGER` with rank equal to that of *MASK*.

Example:

```
program test_count
    integer, dimension(2,3) :: a, b
    logical, dimension(2,3) :: mask
    a = reshape( (/ 1, 2, 3, 4, 5, 6 /), (/ 2, 3 /))
    b = reshape( (/ 0, 7, 3, 4, 5, 8 /), (/ 2, 3 /))
    print '(3i3)', a(1,:)
    print '(3i3)', a(2,:)
    print *
    print '(3i3)', b(1,:)
    print '(3i3)', b(2,:)
    print *
    mask = a.ne.b
    print '(3l3)', mask(1,:)
    print '(3l3)', mask(2,:)
    print *
    print '(3i3)', count(mask)
    print *
    print '(3i3)', count(mask, 1)
    print *
    print '(3i3)', count(mask, 2)
end program test_count
```

7.34 `CPU_TIME` — CPU elapsed time in seconds

Description:
Returns a `REAL` value representing the elapsed CPU time in seconds. This is useful for testing segments of code to determine execution time.

Option: f95, gnu

Class: subroutine

Syntax: `CPU_TIME(X)`

Arguments:

X	The type shall be `REAL` with intent out.

Return value:
None

Example:

```
program test_cpu_time
    real :: start, finish
    call cpu_time(start)
        ! put code to test here
    call cpu_time(finish)
    print '("Time = ",f6.3," seconds.")',finish-start
end program test_cpu_time
```

7.35 `CSHIFT` — Circular shift function

Description:
`CSHIFT(ARRAY, SHIFT[,DIM])` performs a circular shift on elements of *ARRAY* along the dimension of *DIM*. If *DIM* is omitted it is taken to be `1`. *DIM* is

a scaler of type `INTEGER` in the range of $1/leqDIM/leqn)$ where n is the rank of *ARRAY*. If the rank of *ARRAY* is one, then all elements of *ARRAY* are shifted by *SHIFT* places. If rank is greater than one, then all complete rank one sections of *ARRAY* along the given dimension are shifted. Elements shifted out one end of each rank one section are shifted back in the other end.

Option: f95, gnu

Class: transformational function

Syntax: `A = CSHIFT(A, SHIFT[,DIM])`

Arguments:

ARRAY	May be any type, not scaler.
SHIFT	The type shall be `INTEGER`.
DIM	The type shall be `INTEGER`.

Return value:

Returns an array of same type and rank as the *ARRAY* argument.

Example:

```
program test_cshift
    integer, dimension(3,3) :: a
    a = reshape( (/ 1, 2, 3, 4, 5, 6, 7, 8, 9 /), (/ 3, 3 /))
    print '(3i3)', a(1,:)
    print '(3i3)', a(2,:)
    print '(3i3)', a(3,:)
    a = cshift(a, SHIFT=(/1, 2, -1/), DIM=2)
    print *
    print '(3i3)', a(1,:)
    print '(3i3)', a(2,:)
    print '(3i3)', a(3,:)
end program test_cshift
```

7.36 CTIME — Convert a time into a string

Description:

`CTIME(T,S)` converts *T*, a system time value, such as returned by `TIME8()`, to a string of the form '`Sat Aug 19 18:13:14 1995`', and returns that string into *S*.

If `CTIME` is invoked as a function, it can not be invoked as a subroutine, and vice versa.

T is an `INTENT(IN) INTEGER(KIND=8)` variable. *S* is an `INTENT(OUT) CHARACTER` variable.

Option: gnu

Class: subroutine

Syntax:

`CALL CTIME(T,S)`.
`S = CTIME(T)`, (not recommended).

Arguments:

S	The type shall be of type `CHARACTER`.
T	The type shall be of type `INTEGER(KIND=8)`.

Return value:

The converted date and time as a string.

Example:

```
program test_ctime
    integer(8) :: i
    character(len=30) :: date
    i = time8()

    ! Do something, main part of the program

    call ctime(i,date)
    print *, 'Program was started on ', date
end program test_ctime
```

7.37 DATE_AND_TIME — Date and time subroutine

Description:

DATE_AND_TIME(DATE, TIME, ZONE, VALUES) gets the corresponding date and time information from the real-time system clock. *DATE* is INTENT(OUT) and has form ccyymmdd. *TIME* is INTENT(OUT) and has form hhmmss.sss. *ZONE* is INTENT(OUT) and has form (+-)hhmm, representing the difference with respect to Coordinated Universal Time (UTC). Unavailable time and date parameters return blanks.

VALUES is INTENT(OUT) and provides the following:

VALUE(1):	The year
VALUE(2):	The month
VALUE(3):	The day of the month
VAlUE(4):	Time difference with UTC in minutes
VALUE(5):	The hour of the day
VALUE(6):	The minutes of the hour
VALUE(7):	The seconds of the minute
VALUE(8):	The milliseconds of the second

Option: f95, gnu

Class: subroutine

Syntax: CALL DATE_AND_TIME([DATE, TIME, ZONE, VALUES])

Arguments:

DATE	(Optional) The type shall be CHARACTER(8) or larger.
TIME	(Optional) The type shall be CHARACTER(10) or larger.
ZONE	(Optional) The type shall be CHARACTER(5) or larger.
VALUES	(Optional) The type shall be INTEGER(8).

Return value:

None

Example:

```
program test_time_and_date
    character(8)  :: date
    character(10) :: time
```

```
        character(5)  :: zone
        integer,dimension(8) :: values
        ! using keyword arguments
        call date_and_time(date,time,zone,values)
        call date_and_time(DATE=date,ZONE=zone)
        call date_and_time(TIME=time)
        call date_and_time(VALUES=values)
        print '(a,2x,a,2x,a)', date, time, zone
        print '(8i5))', values
    end program test_time_and_date
```

7.38 DBLE — Double conversion function

Description:
: DBLE(X) Converts *X* to double precision real type. DFLOAT is an alias for DBLE

Option: f95, gnu

Class: elemental function

Syntax: X = DBLE(X) X = DFLOAT(X)

Arguments:

X	The type shall be INTEGER(*), REAL(*), or COMPLEX(*).

Return value:
: The return value is of type double precision real.

Example:

```
    program test_dble
        real    :: x = 2.18
        integer :: i = 5
        complex :: z = (2.3,1.14)
        print *, dble(x), dble(i), dfloat(z)
    end program test_dble
```

7.39 DCMPLX — Double complex conversion function

Description:
: DCMPLX(X [,Y]) returns a double complex number where *X* is converted to the real component. If *Y* is present it is converted to the imaginary component. If *Y* is not present then the imaginary component is set to 0.0. If *X* is complex then *Y* must not be present.

Option: f95, gnu

Class: elemental function

Syntax: C = DCMPLX(X) C = DCMPLX(X,Y)

Arguments:

X	The type may be INTEGER(*), REAL(*), or COMPLEX(*).
Y	Optional if *X* is not COMPLEX(*). May be INTEGER(*) or REAL(*).

Return value:
: The return value is of type COMPLEX(8)

Example:
```
program test_dcmplx
    integer :: i = 42
    real :: x = 3.14
    complex :: z
    z = cmplx(i, x)
    print *, dcmplx(i)
    print *, dcmplx(x)
    print *, dcmplx(z)
    print *, dcmplx(x,i)
end program test_dcmplx
```

7.40 DFLOAT — Double conversion function

Description:
DFLOAT(X) Converts *X* to double precision real type. DFLOAT is an alias for DBLE. See DBLE.

7.41 DIGITS — Significant digits function

Description:
DIGITS(X) returns the number of significant digits of the internal model representation of *X*. For example, on a system using a 32-bit floating point representation, a default real number would likely return 24.

Option: f95, gnu

Class: inquiry function

Syntax: C = DIGITS(X)

Arguments:

X	The type may be INTEGER(*) or REAL(*).

Return value:
The return value is of type INTEGER.

Example:
```
program test_digits
    integer :: i = 12345
    real :: x = 3.143
    real(8) :: y = 2.33
    print *, digits(i)
    print *, digits(x)
    print *, digits(y)
end program test_digits
```

7.42 DIM — Dim function

Description:
DIM(X,Y) returns the difference X-Y if the result is positive; otherwise returns zero.

Option: f95, gnu

Class: elemental function

Syntax: X = DIM(X,Y)

Arguments:

X	The type shall be INTEGER(*) or REAL(*)
Y	The type shall be the same type and kind as *X*.

Return value:
The return value is of type INTEGER(*) or REAL(*).

Example:

```
program test_dim
    integer :: i
    real(8) :: x
    i = dim(4, 15)
    x = dim(4.345_8, 2.111_8)
    print *, i
    print *, x
end program test_dim
```

Specific names:

Name	Argument	Return type	Option
IDIM(X,Y)	INTEGER(4) X,Y	INTEGER(4)	gnu
DDIM(X,Y)	REAL(8) X,Y	REAL(8)	gnu

7.43 DOT_PRODUCT — Dot product function

Description:
DOT_PRODUCT(X,Y) computes the dot product multiplication of two vectors *X* and *Y*. The two vectors may be either numeric or logical and must be arrays of rank one and of equal size. If the vectors are INTEGER(*) or REAL(*), the result is SUM(X*Y). If the vectors are COMPLEX(*), the result is SUM(CONJG(X)*Y). If the vectors are LOGICAL, the result is ANY(X.AND.Y).

Option: f95

Class: transformational function

Syntax: S = DOT_PRODUCT(X,Y)

Arguments:

X	The type shall be numeric or LOGICAL, rank 1.
Y	The type shall be numeric or LOGICAL, rank 1.

Return value:
If the arguments are numeric, the return value is a scaler of numeric type, INTEGER(*), REAL(*), or COMPLEX(*). If the arguments are LOGICAL, the return value is .TRUE. or .FALSE..

Example:

```
program test_dot_prod
    integer, dimension(3) :: a, b
    a = (/ 1, 2, 3 /)
    b = (/ 4, 5, 6 /)
    print '(3i3)', a
    print *
    print '(3i3)', b
```

```
    print *
    print *, dot_product(a,b)
end program test_dot_prod
```

7.44 DPROD — Double product function

Description:
DPROD(X,Y) returns the product X*Y.

Option: f95, gnu

Class: elemental function

Syntax: D = DPROD(X,Y)

Arguments:

X	The type shall be REAL.
Y	The type shall be REAL.

Return value:
The return value is of type REAL(8).

Example:

```
program test_dprod
    integer :: i
    real :: x = 5.2
    real :: y = 2.3
    real(8) :: d
    d = dprod(x,y)
    print *, d
end program test_dprod
```

7.45 DREAL — Double real part function

Description:
DREAL(Z) returns the real part of complex variable *Z*.

Option: gnu

Class: elemental function

Syntax: D = DREAL(Z)

Arguments:

Z	The type shall be COMPLEX(8).

Return value:
The return value is of type REAL(8).

Example:

```
program test_dreal
    complex(8) :: z = (1.3_8,7.2_8)
    print *, dreal(z)
end program test_dreal
```

7.46 DTIME — Execution time subroutine (or function)

Description:

DTIME(TARRAY, RESULT) initially returns the number of seconds of runtime since the start of the process's execution in *RESULT*. *TARRAY* returns the user and system components of this time in TARRAY(1) and TARRAY(2) respectively. *RESULT* is equal to TARRAY(1) + TARRAY(2).

Subsequent invocations of DTIME return values accumulated since the previous invocation.

On some systems, the underlying timings are represented using types with sufficiently small limits that overflows (wraparounds) are possible, such as 32-bit types. Therefore, the values returned by this intrinsic might be, or become, negative, or numerically less than previous values, during a single run of the compiled program.

If DTIME is invoked as a function, it can not be invoked as a subroutine, and vice versa.

TARRAY and *RESULT* are INTENT(OUT) and provide the following:

TARRAY(1):	User time in seconds.
TARRAY(2):	System time in seconds.
RESULT:	Run time since start in seconds.

Option: gnu

Class: subroutine

Syntax:

CALL DTIME(TARRAY, RESULT).
RESULT = DTIME(TARRAY), (not recommended).

Arguments:

TARRAY	The type shall be REAL, DIMENSION(2).
RESULT	The type shall be REAL.

Return value:

Elapsed time in seconds since the start of program execution.

Example:

```
program test_dtime
    integer(8) :: i, j
    real, dimension(2) :: tarray
    real :: result
    call dtime(tarray, result)
    print *, result
    print *, tarray(1)
    print *, tarray(2)
    do i=1,100000000    ! Just a delay
        j = i * i - i
    end do
    call dtime(tarray, result)
    print *, result
    print *, tarray(1)
    print *, tarray(2)
end program test_dtime
```

7.47 EOSHIFT — End-off shift function

Description:

EOSHIFT(ARRAY, SHIFT[,BOUNDARY, DIM]) performs an end-off shift on elements of *ARRAY* along the dimension of *DIM*. If *DIM* is omitted it is taken to be 1. *DIM* is a scaler of type INTEGER in the range of $1/leqDIM/leqn)$ where n is the rank of *ARRAY*. If the rank of *ARRAY* is one, then all elements of *ARRAY* are shifted by *SHIFT* places. If rank is greater than one, then all complete rank one sections of *ARRAY* along the given dimension are shifted. Elements shifted out one end of each rank one section are dropped. If *BOUNDARY* is present then the corresponding value of from *BOUNDARY* is copied back in the other end. If *BOUNDARY* is not present then the following are copied in depending on the type of *ARRAY*.

Array Type	*Boundary Value*
Numeric	0 of the type and kind of *ARRAY*.
Logical	.FALSE..
Character(*len*)	*len* blanks.

Option: f95, gnu

Class: transformational function

Syntax: A = EOSHIFT(A, SHIFT[,BOUNDARY, DIM])

Arguments:

ARRAY	May be any type, not scaler.
SHIFT	The type shall be INTEGER.
BOUNDARY	Same type as *ARRAY*.
DIM	The type shall be INTEGER.

Return value:

Returns an array of same type and rank as the *ARRAY* argument.

Example:

```
program test_eoshift
    integer, dimension(3,3) :: a
    a = reshape( (/ 1, 2, 3, 4, 5, 6, 7, 8, 9 /), (/ 3, 3 /))
    print '(3i3)', a(1,:)
    print '(3i3)', a(2,:)
    print '(3i3)', a(3,:)
    a = EOSHIFT(a, SHIFT=(/1, 2, 1/), BOUNDARY=-5, DIM=2)
    print *
    print '(3i3)', a(1,:)
    print '(3i3)', a(2,:)
    print '(3i3)', a(3,:)
end program test_eoshift
```

7.48 EPSILON — Epsilon function

Description:

EPSILON(X) returns a nearly negligible number relative to 1.

Option: f95, gnu

Class: inquiry function

Syntax: `C = EPSILON(X)`

Arguments:

X	The type shall be `REAL(*)`.

Return value:
The return value is of same type as the argument.

Example:

```
program test_epsilon
    real :: x = 3.143
    real(8) :: y = 2.33
    print *, EPSILON(x)
    print *, EPSILON(y)
end program test_epsilon
```

7.49 ERF — Error function

Description:
`ERF(X)` computes the error function of *X*.

Option: gnu

Class: elemental function

Syntax: `X = ERF(X)`

Arguments:

X	The type shall be `REAL(*)`, and it shall be scalar.

Return value:
The return value is a scalar of type `REAL(*)` and it is positive ($-1 \leq erf(x) \leq 1$.

Example:

```
program test_erf
  real(8) :: x = 0.17_8
  x = erf(x)
end program test_erf
```

Specific names:

Name	Argument	Return type	Option
`DERF(X)`	`REAL(8) X`	`REAL(8)`	gnu

7.50 ERFC — Error function

Description:
`ERFC(X)` computes the complementary error function of *X*.

Option: gnu

Class: elemental function

Syntax: `X = ERFC(X)`

Arguments:

X	The type shall be `REAL(*)`, and it shall be scalar.

Return value:
The return value is a scalar of type `REAL(*)` and it is positive ($0 \leq erfc(x) \leq 2$.

Example:
```
program test_erfc
  real(8) :: x = 0.17_8
  x = erfc(x)
end program test_erfc
```

Specific names:

Name	Argument	Return type	Option
`DERFC(X)`	`REAL(8) X`	`REAL(8)`	gnu

7.51 ETIME — Execution time subroutine (or function)

Description:
`ETIME(TARRAY, RESULT)` returns the number of seconds of runtime since the start of the process's execution in *RESULT*. *TARRAY* returns the user and system components of this time in `TARRAY(1)` and `TARRAY(2)` respectively. *RESULT* is equal to `TARRAY(1) + TARRAY(2)`.

On some systems, the underlying timings are represented using types with sufficiently small limits that overflows (wraparounds) are possible, such as 32-bit types. Therefore, the values returned by this intrinsic might be, or become, negative, or numerically less than previous values, during a single run of the compiled program.

If `ETIME` is invoked as a function, it can not be invoked as a subroutine, and vice versa.

TARRAY and *RESULT* are `INTENT(OUT)` and provide the following:

`TARRAY(1)`:	User time in seconds.
`TARRAY(2)`:	System time in seconds.
`RESULT`:	Run time since start in seconds.

Option: gnu

Class: subroutine

Syntax:
`CALL ETIME(TARRAY, RESULT)`.
`RESULT = ETIME(TARRAY)`, (not recommended).

Arguments:

TARRAY	The type shall be `REAL, DIMENSION(2)`.
RESULT	The type shall be `REAL`.

Return value:
Elapsed time in seconds since the start of program execution.

Example:
```
program test_etime
    integer(8) :: i, j
    real, dimension(2) :: tarray
    real :: result
```

```
    call ETIME(tarray, result)
    print *, result
    print *, tarray(1)
    print *, tarray(2)
    do i=1,100000000    ! Just a delay
        j = i * i - i
    end do
    call ETIME(tarray, result)
    print *, result
    print *, tarray(1)
    print *, tarray(2)
end program test_etime
```

7.52 EXIT — Exit the program with status.

Description:
EXIT causes immediate termination of the program with status. If status is omitted it returns the canonical *success* for the system. All Fortran I/O units are closed.

Option: gnu

Class: non-elemental subroutine

Syntax: CALL EXIT([STATUS])

Arguments:

STATUS	The type of the argument shall be INTEGER(*).

Return value:
STATUS is passed to the parent process on exit.

Example:

```
program test_exit
  integer :: STATUS = 0
  print *, 'This program is going to exit.'
  call EXIT(STATUS)
end program test_exit
```

7.53 EXP — Exponential function

Description:
EXP(X) computes the base e exponential of X.

Option: f95, gnu

Class: elemental function

Syntax: X = EXP(X)

Arguments:

X	The type shall be REAL(*) or COMPLEX(*).

Return value:
The return value has same type and kind as X.

Example:

```
program test_exp
  real :: x = 1.0
  x = exp(x)
end program test_exp
```

Specific names:

Name	Argument	Return type	Option
DEXP(X)	REAL(8) X	REAL(8)	f95, gnu
CEXP(X)	COMPLEX(4) X	COMPLEX(4)	f95, gnu
ZEXP(X)	COMPLEX(8) X	COMPLEX(8)	f95, gnu
CDEXP(X)	COMPLEX(8) X	COMPLEX(8)	f95, gnu

7.54 EXPONENT — Exponent function

Description:
EXPONENT(X) returns the value of the exponent part of *X*. If *X* is zero the value returned is zero.

Option: f95, gnu

Class: elemental function

Syntax: I = EXPONENT(X)

Arguments:

X	The type shall be REAL(*).

Return value:
The return value is of type default INTEGER.

Example:

```
program test_exponent
  real :: x = 1.0
  integer :: i
  i = exponent(x)
  print *, i
  print *, exponent(0.0)
end program test_exponent
```

7.55 FDATE — Get the current time as a string

Description:
FDATE(DATE) returns the current date (using the same format as CTIME) in *DATE*. It is equivalent to CALL CTIME(DATE, TIME8()).

If FDATE is invoked as a function, it can not be invoked as a subroutine, and vice versa.

DATE is an INTENT(OUT) CHARACTER variable.

Option: gnu

Class: subroutine

Syntax:

CALL FDATE(DATE).
DATE = FDATE(), (not recommended).

Arguments:

DATE	The type shall be of type `CHARACTER`.

Return value:
The current date and time as a string.

Example:

```
program test_fdate
    integer(8) :: i, j
    character(len=30) :: date
    call fdate(date)
    print *, 'Program started on ', date
    do i = 1, 100000000 ! Just a delay
        j = i * i - i
    end do
    call fdate(date)
    print *, 'Program ended on ', date
end program test_fdate
```

7.56 `FLOOR` — Integer floor function

Description:
`FLOOR(X)` returns the greatest integer less than or equal to *X*.

Option: f95, gnu

Class: elemental function

Syntax: `I = FLOOR(X[,KIND])`

Arguments:

X	The type shall be `REAL(*)`.
KIND	Optional scaler integer initialization expression.

Return value:
The return value is of type `INTEGER(KIND)`

Example:

```
program test_floor
    real :: x = 63.29
    real :: y = -63.59
    print *, floor(x) ! returns 63
    print *, floor(y) ! returns -64
end program test_floor
```

7.57 `FNUM` — File number function

Description:
`FNUM(UNIT)` returns the Posix file descriptor number coresponding to the open Fortran I/O unit `UNIT`.

Option: gnu

Class: non-elemental function

Syntax: `I = FNUM(UNIT)`

Arguments:

UNIT	The type shall be INTEGER.

Return value:
The return value is of type INTEGER

Example:

```
program test_fnum
  integer :: i
  open (unit=10, status = "scratch")
  i = fnum(10)
  print *, i
  close (10)
end program test_fnum
```

7.58 LOG — Logarithm function

Description:
LOG(X) computes the logarithm of *X*.

Option: f95, gnu

Class: elemental function

Syntax: X = LOG(X)

Arguments:

X	The type shall be REAL(*) or COMPLEX(*).

Return value:
The return value is of type REAL(*) or COMPLEX(*). The kind type parameter is the same as *X*.

Example:

```
program test_log
  real(8) :: x = 1.0_8
  complex :: z = (1.0, 2.0)
  x = log(x)
  z = log(z)
end program test_log
```

Specific names:

Name	Argument	Return type	Option
ALOG(X)	REAL(4) X	REAL(4)	f95, gnu
DLOG(X)	REAL(8) X	REAL(8)	f95, gnu
CLOG(X)	COMPLEX(4) X	COMPLEX(4)	f95, gnu
ZLOG(X)	COMPLEX(8) X	COMPLEX(8)	f95, gnu
CDLOG(X)	COMPLEX(8) X	COMPLEX(8)	f95, gnu

7.59 LOG10 — Base 10 logarithm function

Description:
LOG10(X) computes the base 10 logarithm of *X*.

Option: f95, gnu

Class: elemental function

Syntax: `X = LOG10(X)`

Arguments:

X	The type shall be `REAL(*)` or `COMPLEX(*)`.

Return value:
The return value is of type `REAL(*)` or `COMPLEX(*)`. The kind type parameter is the same as *X*.

Example:

```
program test_log10
  real(8) :: x = 10.0_8
  x = log10(x)
end program test_log10
```

Specific names:

Name	Argument	Return type	Option
`ALOG10(X)`	`REAL(4) X`	`REAL(4)`	f95, gnu
`DLOG10(X)`	`REAL(8) X`	`REAL(8)`	f95, gnu

7.60 `SECNDS` — Time subroutine

Description:
`SECNDS(X)` gets the time in seconds from the real-time system clock. *X* is a reference time, also in seconds. If this is zero, the time in seconds from midnight is returned. This function is non-standard and its use is discouraged.

Option: gnu

Class: function

Syntax: `T = SECNDS (X)`

Arguments:

Name	Type
T	REAL(4)
X	REAL(4)

Return value:
None

Example:

```
program test_secnds
    real(4) :: t1, t2
    print *, secnds (0.0)   ! seconds since midnight
    t1 = secnds (0.0)       ! reference time
    do i = 1, 10000000      ! do something
    end do
    t2 = secnds (t1)        ! elapsed time
    print *, "Something took ", t2, " seconds."
end program test_secnds
```

7.61 SIN — Sine function

Description:
SIN(X) computes the sine of *X*.

Option: f95, gnu

Class: elemental function

Syntax: X = SIN(X)

Arguments:

X	The type shall be REAL(*) or COMPLEX(*).

Return value:
The return value has same type and king than *X*.

Example:

```
program test_sin
  real :: x = 0.0
  x = sin(x)
end program test_sin
```

Specific names:

Name	Argument	Return type	Option
DSIN(X)	REAL(8) X	REAL(8)	f95, gnu
CSIN(X)	COMPLEX(4) X	COMPLEX(4)	f95, gnu
ZSIN(X)	COMPLEX(8) X	COMPLEX(8)	f95, gnu
CDSIN(X)	COMPLEX(8) X	COMPLEX(8)	f95, gnu

7.62 SINH — Hyperbolic sine function

Description:
SINH(X) computes the hyperbolic sine of *X*.

Option: f95, gnu

Class: elemental function

Syntax: X = SINH(X)

Arguments:

X	The type shall be REAL(*).

Return value:
The return value is of type REAL(*).

Example:

```
program test_sinh
  real(8) :: x = - 1.0_8
  x = sinh(x)
end program test_sinh
```

Specific names:

Name	Argument	Return type	Option
DSINH(X)	REAL(8) X	REAL(8)	f95, gnu

7.63 SQRT — Square-root function

Description:
: `SQRT(X)` computes the square root of *X*.

Option: f95, gnu

Class: elemental function

Syntax: `X = SQRT(X)`

Arguments:

X	The type shall be `REAL(*)` or `COMPLEX(*)`.

Return value:
: The return value is of type `REAL(*)` or `COMPLEX(*)`. The kind type parameter is the same as *X*.

Example:

```
program test_sqrt
  real(8) :: x = 2.0_8
  complex :: z = (1.0, 2.0)
  x = sqrt(x)
  z = sqrt(z)
end program test_sqrt
```

Specific names:

Name	Argument	Return type	Option
`DSQRT(X)`	`REAL(8) X`	`REAL(8)`	f95, gnu
`CSQRT(X)`	`COMPLEX(4) X`	`COMPLEX(4)`	f95, gnu
`ZSQRT(X)`	`COMPLEX(8) X`	`COMPLEX(8)`	f95, gnu
`CDSQRT(X)`	`COMPLEX(8) X`	`COMPLEX(8)`	f95, gnu

7.64 TAN — Tangent function

Description:
: `TAN(X)` computes the tangent of *X*.

Option: f95, gnu

Class: elemental function

Syntax: `X = TAN(X)`

Arguments:

X	The type shall be `REAL(*)`.

Return value:
: The return value is of type `REAL(*)`. The kind type parameter is the same as *X*.

Example:

```
program test_tan
  real(8) :: x = 0.165_8
  x = tan(x)
end program test_tan
```

Specific names:

Name	Argument	Return type	Option
DTAN(X)	REAL(8) X	REAL(8)	f95, gnu

7.65 TANH — Hyperbolic tangent function

Description:
TANH(X) computes the hyperbolic tangent of *X*.

Option: f95, gnu

Class: elemental function

Syntax: X = TANH(X)

Arguments:

X	The type shall be REAL(*).

Return value:
The return value is of type REAL(*) and lies in the range $-1 \leq tanh(x) \leq 1$.

Example:

```
program test_tanh
  real(8) :: x = 2.1_8
  x = tanh(x)
end program test_tanh
```

Specific names:

Name	Argument	Return type	Option
DTANH(X)	REAL(8) X	REAL(8)	f95, gnu

8 Contributing

Free software is only possible if people contribute to efforts to create it. We're always in need of more people helping out with ideas and comments, writing documentation and contributing code.

If you want to contribute to GNU Fortran 95, have a look at the long lists of projects you can take on. Some of these projects are small, some of them are large; some are completely orthogonal to the rest of what is happening on `gfortran`, but others are "mainstream" projects in need of enthusiastic hackers. All of these projects are important! We'll eventually get around to the things here, but they are also things doable by someone who is willing and able.

8.1 Contributors to GNU Fortran 95

Most of the parser was hand-crafted by *Andy Vaught*, who is also the initiator of the whole project. Thanks Andy! Most of the interface with GCC was written by *Paul Brook*.

The following individuals have contributed code and/or ideas and significant help to the gfortran project (in no particular order):

- Andy Vaught
- Katherine Holcomb
- Tobias Schlter
- Steven Bosscher
- Toon Moene
- Tim Prince
- Niels Kristian Bech Jensen
- Steven Johnson
- Paul Brook
- Feng Wang
- Bud Davis

The following people have contributed bug reports, smaller or larger patches, and much needed feedback and encouragement for the `gfortran` project:

- Erik Schnetter
- Bill Clodius
- Kate Hedstrom

Many other individuals have helped debug, test and improve `gfortran` over the past two years, and we welcome you to do the same! If you already have done so, and you would like to see your name listed in the list above, please contact us.

8.2 Projects

Help build the test suite

Solicit more code for donation to the test suite. We can keep code private on request.

Bug hunting/squishing
: Find bugs and write more test cases! Test cases are especially very welcome, because it allows us to concentrate on fixing bugs instead of isolating them.

Smaller projects ("bug" fixes):
- Allow init exprs to be numbers raised to integer powers.
- Implement correct rounding.
- Implement F restrictions on Fortran 95 syntax.
- See about making Emacs-parsable error messages.

If you wish to work on the runtime libraries, please contact a project maintainer.

9 Standards

The GNU Fortran 95 Compiler aims to be a conforming implementation of ISO/IEC 1539:1997 (Fortran 95).

In the future it may also support other variants and extensions to the Fortran language. This includes ANSI Fortran 77, Fortran 90, Fortran 2000 (not yet finalized), and OpenMP.

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